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JUNE 14, 1956
EVERY OTHER THURSDAY

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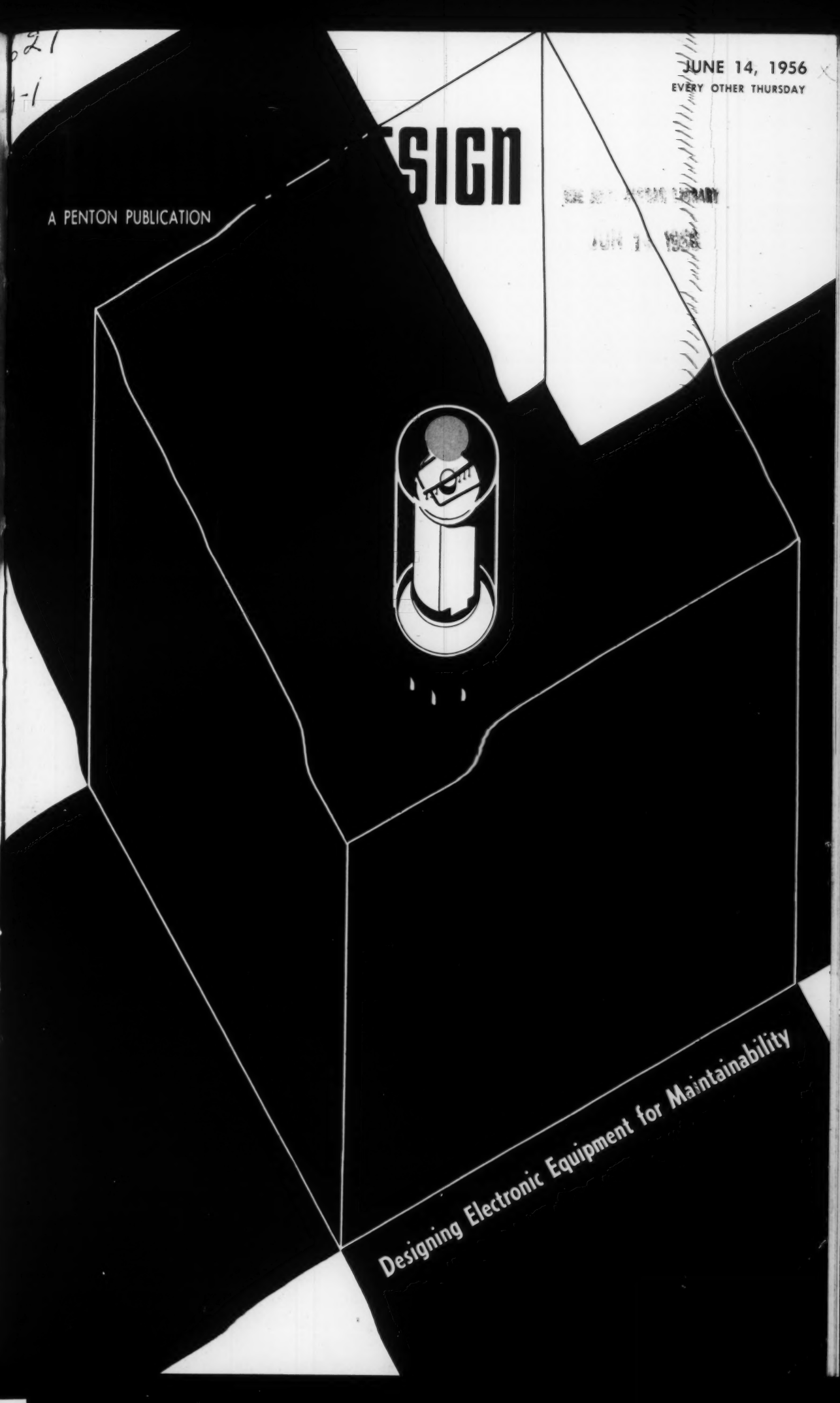
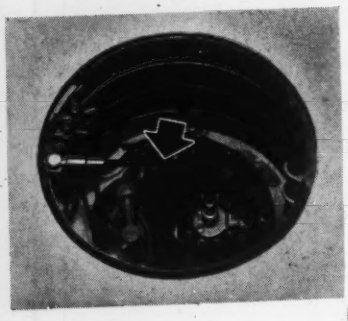


Designing Electronic Equipment for Maintainability

FLEXIBLE SHAFT IDEAS for ENGINEERS

4 Ways to put a flexible shaft's adaptability to profitable use in machine design

A few of the common design problems you can solve with S.S.WHITE FLEXIBLE SHAFTS

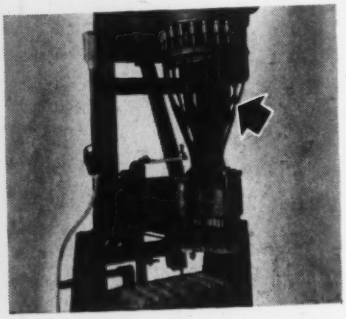


Control of Inaccessible Parts

Even though a rotary switch shown here was located in an inaccessible spot, an S.S.White remote control flexible shaft allows it to be operated from a conveniently positioned control knob on the outside of the equipment. Note that only one shaft is needed to do the job.

Weight Reduction

Electric portable tools can be mighty heavy to handle and difficult to manipulate especially when they need a big motor to drive them. A flexible shaft drive such as the one shown here is the logical solution since it removes the weight of the motor from the operator's hands.



Greater Versatility

The ability of a flexible shaft to be set in a wide range of operating positions is a big advantage in designing equipment like this multiple spindle drill press. The flexible shaft spindles can be set in any desired grouping to meet the requirements of different drilling jobs.

Ideas that may help you design better drives and controls

1. Eliminating Alignment Problems

Where misalignment exists, or where accurate alignment of drive and control elements is likely to be costly and time-consuming, an S.S.White flexible shaft is a "must." The flexible shaft automatically compensates for misalignment, thereby simplifying assembly and eliminating possible operating troubles.

2. Providing Adjustable Drives

Where there is relative movement between driving and driven parts, or where the driven part must be moved or adjusted in operation, an S.S.White power drive flexible shaft is an economical, dependable way to transmit power between the two. The shaft readily adapts itself to any operating position and is capable of giving long trouble-free service.

3. Gaining Extra Design Freedom

Consider the use of S.S.White flexible shafts if you want to gain greater freedom in positioning drive and control elements in their most desirable locations. It will simplify the job of meeting specific operating and service requirements.

4. Satisfying Space Limitations

Flexible shafts are more adaptable, less complicated, less expensive and considerably more compact than systems of bevel gears, straight shafts, belts, pulleys, etc. Their use allows you to develop more efficient, more compact equipment.

FLEXIBLE SHAFT INFORMATION

Bulletin 5601, a helpful informative guide on flexible shaft construction, selection and application, will be sent on request. Write for your copy.

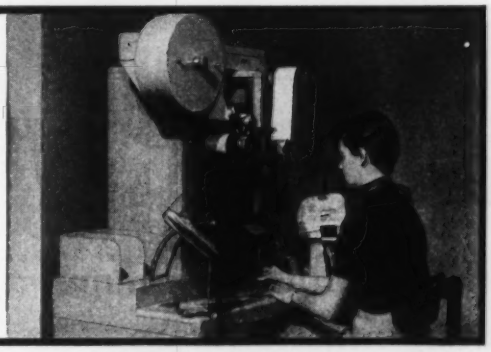
F6-6

FIRST NAME IN FLEXIBLE SHAFTS

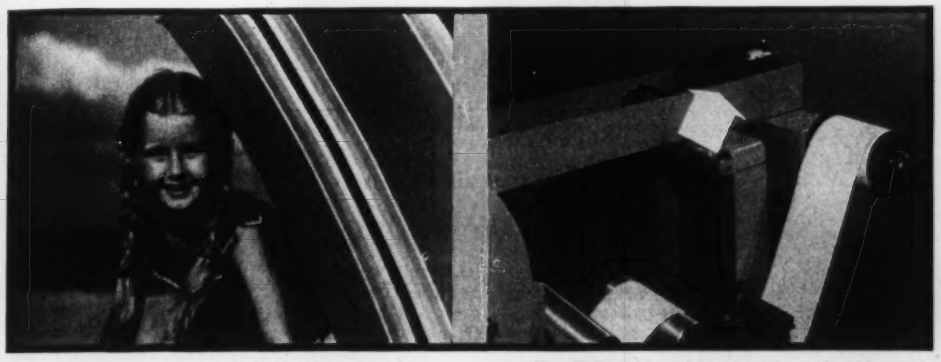
S. S. WHITE INDUSTRIAL DIVISION, DEPT. 4, 10 EAST 40th ST., NEW YORK 16, N.Y.

Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

Why Bodine motors were selected for Pakomatic picture printers



1 This machine is a Pakomatic printer made by Pako Corporation, Minneapolis. With it, the average operator can produce over 1000 photo prints an hour.



2 Fast, accurate, automatic timing correctly exposes negatives...enables operators to produce high quality prints, like this.

3 The Pakomatic printer is powered with two Bodine fractional horsepower motors...this 1/150 HP motor at the top of the printer, which powers the take-up roller...

4 ...and this 1/15 HP, double-shaft Bodine Motor which powers the gear box and projection lamp cooling blower of the Pakomatic printer.

5 We'd like to have you meet Mr. Harry Dye, president of Pako Corporation, manufacturer of Pakomatic printers.

"Bodine Motors have satisfactorily provided the power, compactness, and durability required for the operation of many Pako products. Since 1932, our needs for special motors have included types with various gear reduction ratios, double shaft drive, universal current, and reversible operation. Bodine Motors have filled the bill for Pako at a satisfactory price."

BODINE

BODINE

fractional horsepower

MOTORS

6 Why does Pako Corporation use Bodine Motors?...Mr. Dye gives a number of good reasons. See above.

7 Be sure your motor is as good as your product. For details, contact Bodine Electric Co., 2258 W. Ohio St., Chicago...or check your **Sweet's file.**

BODINE MANUFACTURES FRACTIONAL HORSEPOWER ELECTRIC MOTORS FOR:

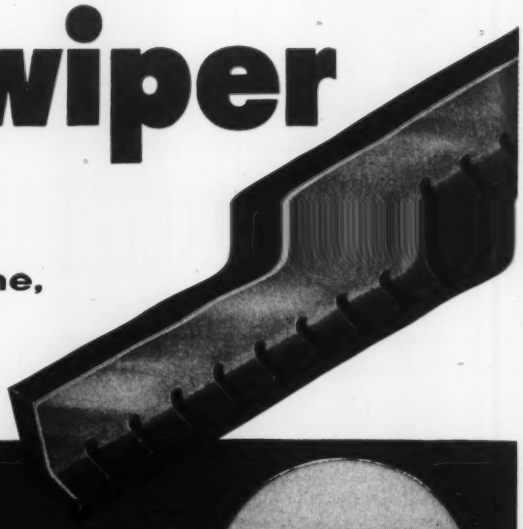
adding machines
letter openers
sanders
vending machines
exhaust fans
duplicating machines
portable tools
sound recorders
air conditioners
check protectors
respirators
voltage regulators
x-ray timers
traffic signal timers
stirrers
calculating machines
envelope sealers
diesel governors

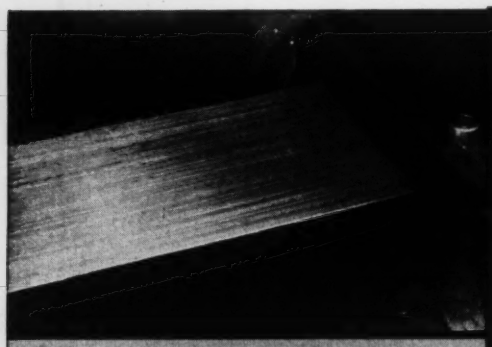
... and for many other applications.

Ask for a sample copy of 'The Motorgram,' a bi-monthly publication discussing the application and design of fractional horsepower electric motors.

NEW, BETTER C/R way wiper

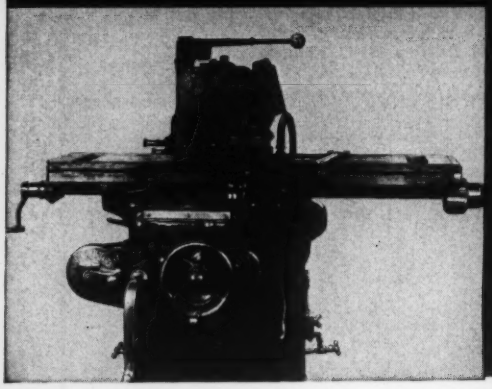
guards the life, cuts downtime, saves costly maintenance on machine tool ways



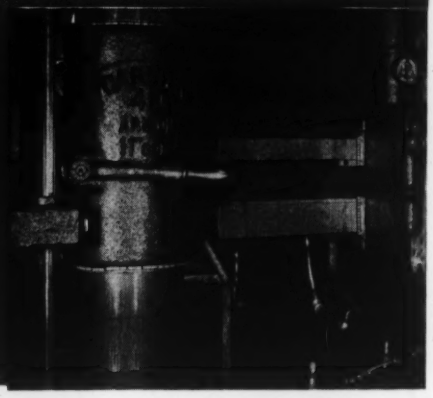


This close-up photograph shows harmful chips and abrasives trapped in a fibrous wiper that permitted scoring of the lathe way shown at left.

The extent of scoring and abrasion caused by chips trapped under the carriage is clearly shown in this photograph of a lathe way.



C/R Way Wipers are quickly, easily installed on this milling machine, as well as on shapers, grinders, planers, and gear cutters.



The clean, score-free wiping action of C/R Way Wipers is evident again in this partial view of a radial drill. Note how close, accurate lip contact on the column is achieved, even though the wiper is mounted on uneven surfaces.

How many hundreds of dollars are scoring and abrasion of machine tool ways costing your shop each year . . . dollars that could easily be saved? C/R Sirvene (synthetic rubber) Way Wipers make it unnecessary to tolerate this expensive damage. They are designed and precision molded for an extremely accurate fit. They will *not* trap harmful materials . . . will not mark or smudge ways. They will wipe ways clean of dirt, chips, fine abrasives . . . even water emulsions . . . yet leave a thin, protective oil film. C/R Sirvene Way Wipers will fit flat ways, side rails, angles, columns and hydraulic rams . . . and are easily installed. They will save you many times their cost. Please write for illustrated brochure that gives complete details.

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Offices in 55 principal cities. See your telephone book

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Export Sales: Geon International Corp., Great Neck, New York

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CHICAGO RAWHIDE

Other C/R Products
C/R Shaft and End Face Seals • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears

—ITEM 505—
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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

June 14, 1956
Volume 28—No. 12

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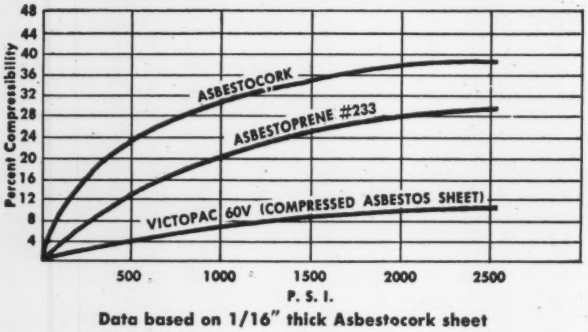
Compressibility of Asbestocork compared with other Victor asbestos-synthetic rubber packings



Data based on 1/16" thick Asbestocork sheet

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For Automotive and Industrial Sealing

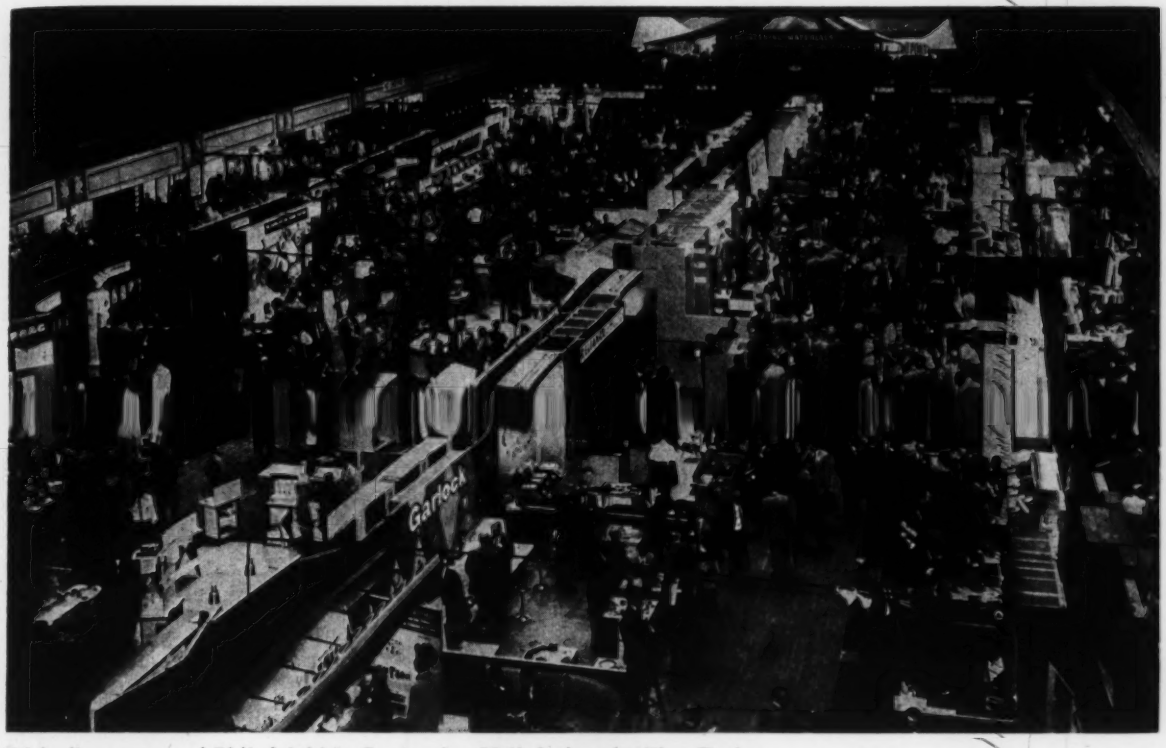
Asbestocork was developed especially for its wide usefulness in automotive and industrial sealing on light to medium pressures. Thorough tests on recommended applications show new levels of performance. The added advantage of economy makes it imperative that you know all about *Asbestocork*. Available in standard thicknesses, 1/32" to 1/8".

Sample Sheet and Technical Data on Request

Your inquiry invited; no obligation. Please state proposed application. Prices quoted on sheet stock or finished gaskets if desired. Victor's highly developed rule die-cutting technique assures big savings on finished gaskets in any quantity.

Contact your Victor Field Engineer, or address Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill. In Canada: Victor Mfg. & Gasket Co. of Canada Ltd., Victor Drive & Chester St., St. Thomas, Ont.

Engineering News Roundup



Main-floor arena of Philadelphia's Convention Hall during the First Design Engineering Show. Other exhibits were located in the hall's lower-level arena.

Audience at one of the Conference sessions. Talks and panel discussions were presented during four sessions by A. D. Bentley and W. L. Healy, both of General Electric Co.; Prof. Chester Linsky, Pennsylvania State University, A. A. Johnson, Westinghouse Electric Corp., and Dr. Bernard J. Covner, Dunlap & Associates; W. A. Irvine, Maytag Co., and William C. Schmidt, Bell Telephone Laboratories; W. A. Steiger, Westinghouse Electric Corp., and George A. Woodling, Cleveland patent attorney.

Attendance Tops 13,000 At Design Engineering Show

High Interest Shown In Conference Sessions

PHILADELPHIA, PA. — Convention Hall was the scene of an impressive gathering of design engineers during the First Design Engineering Show and Conference, May 14-17. Attendance during the four days exceeded 13,000. The Machine Design Division of ASME reported 1265 conference registrants.

Conference sessions, which took place in the mornings, dealt with value analysis in design, obtaining and training engineers, selecting engineering materials, problems in miniaturization, recognizing and rewarding invention, and the rights of employees' inventions. Authorities on each of these subjects presented talks, which were followed by questions and discus-

FIRST-AWARD PLAQUE is presented to Colin Carmichael (right), editor of *Machine Design*, by G. D. Crain Jr., publisher of *Industrial Marketing*, for the best single article entered in the industrial publications division of the 18th Annual Business Paper Editorial Achievement Competition. The article was "When to Specify Special Motors," which appeared in the November, 1955, issue. A certificate of merit was also presented to *Machine Design* for the series of articles, "Adjustable-Speed Drives," which appeared in October, 1954 and April, June and October, 1955.

sion from the audience.

Products and services essential to the design engineering function were displayed by 178 exhibitors.

Plans are already under way for a second design show and conference, to be held in New York City's Coliseum the week of May 20, 1957.

Magnesium Parts Give AC Motors Light Weight

OWOSSO, MICH.—New models of ac electric motors made by Redmond Co. Inc. have stator shells and end frames of magnesium, resulting in weight savings of more than a pound per motor. Also contributing to weight savings are newly designed stator laminations.

The new models have ratings from 1/35 to ¼ hp. Redmond claims to be the first manufacturer to use magnesium in high-production motors in this range.

Stator laminations in the new units are flattened at four equally spaced points on their periphery. Redmond says this design permits use of narrower sheet stock and reduces the weight of scrap. The stators are die-cast around the lamination stock in a Redmond Uni-Cast process. End frames are die cast by a high-speed hot chamber process.

Lamination stock of Redmond motor is inserted in die of magnesium casting machine. Stator is then cast around insert.

Automation Paces Growth Of Business Records

HAWTHORNE, CALIF. — In dedication ceremonies which recently opened the Electronics Div. of National Cash Register Co., Stanley C. Allyn, president of NCR, forecast an "impending revolution" in the keeping of records and the operation of business offices. "Office routines," he said, "are on the verge of the most sweeping changes since the advent of the cash register and the adding machine in the late 1900's."

Foremost among the factors causing this revolution, Mr. Allyn indicated, is the rapid advance in clerical costs as a result of the rising wage level and the mounting burden of paper work. While at the turn of the century only one employee in 40 was a "paper" worker, today there is one clerical employee among every six workers.

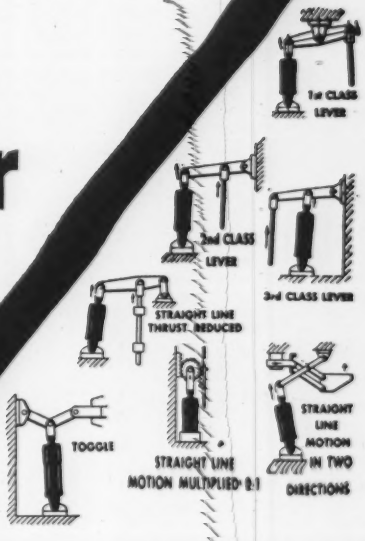
Another factor encouraging business automation is the rising economic status of millions of Americans in the middle income group. "During the past 15 years," Mr. Allyn said "the number of checking accounts has doubled to 50 million. An estimated 9 billion checks are written each year. There are over 125 million new life insurance policies and millions of new mortgages and installment loan accounts." Electronic systems will "dig American business out from under its mountain of paper," he asserted.

NCR's commercial electronics development program has three objectives, Mr. Allyn pointed out, all aiming at solving "paper" problems with speed, efficiency and economy. First is the adaptation of conventional cash registers and

Front Cover

An "unfolded" electronics package by cover artist George Farnsworth keynotes a new series of articles on designing electronic equipment for maintainability. The series, by John D. Folley Jr. and James W. Altman, outlines design methods to "build in" low-cost maintenance features into all types of electronic equipment.

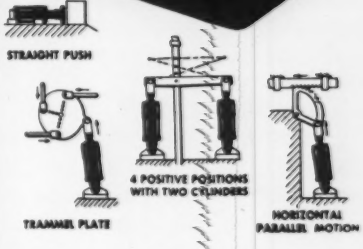
...how can I use HANNA® cylinder power in my machine tools and equipment?



IF YOU HAVE a push, pull, lift, press, clamp or control problem, Hanna Cylinder Power can be the answer. The mechanical movements here illustrated may suggest ways Hanna Cylinders can be used to simplify the actuation and control of machines or equipment and to replace or reduce manual effort.

In the majority of cases, you can select a standard cylinder model to meet your specific requirements from the broad Hanna Hydraulic and Pneumatic lines. Regardless of whether you choose a "standard" or "special" the Hanna label assures you of quality developed through fifty years of concentration on cylinders and their control valves!

here are basic Cylinder Powered MECHANICAL MOVEMENTS that can be put to work for YOU!



SEND for your Free copies of these valuable Hanna Catalogs:

No. 236B HANNA LOW PRESSURE CYLINDERS
No. 233B HANNA HIGH PRESSURE CYLINDERS
No. 750A HANNA MEDIUM PRESSURE CYLINDERS
No. 254 HANNA CONTROL VALVES

Hanna Engineering Works

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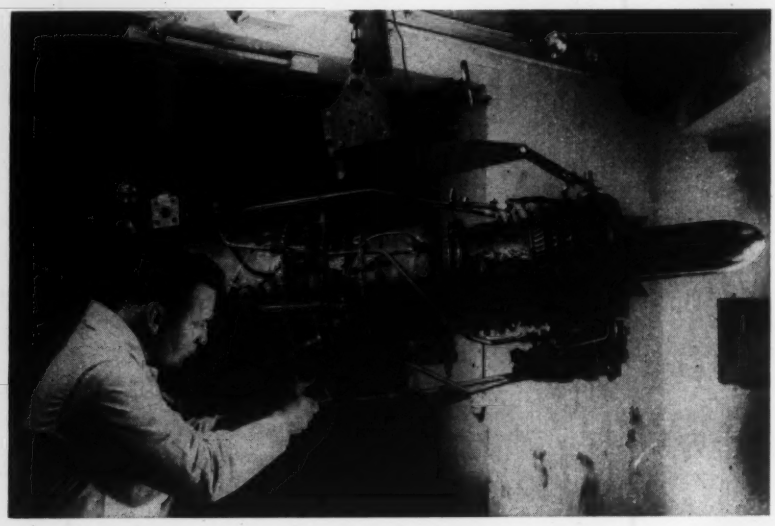
HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

business machines to serve as a means of original entry and input devices for computers. This has been accomplished by equipping these machines with punched tape recorders. Second objective is to produce a complete computing system, consisting of the computer plus all necessary input and output devices and other periphery units. Third part of the program is the thorough survey of system needs in different types of business and the practical application of electronics to their accounting problems.



Turboshaft engine developed by General Electric for the Navy Bureau of Aeronautics is designated T-58. It will develop more than 1000 hp in 59-in., 325-lb frame. Engine features low specific fuel consumption and high power-to-weight ratio. The T-58 uses fluid type power transmission.

New Aircraft Gas Turbine Has High Power, Low Weight

T-58 is Mighty Mite For Helicopters

WASHINGTON, D. C.—The T-58 aircraft gas turbine engine, described as "pound-for-pound the most powerful turboshaft yet announced," has been developed for the Navy by the General Electric Co.

The T-58 produces more than 1000 hp and weighs 325 pounds, including gearing. According to GE, this is the most favorable power-to-weight ratio of any similar engine in the medium-small class of powerplants.

The T-58 is less than 5 ft long and 16 in. in diameter. Specific fuel consumption was announced as 0.69 lb per hr per hp at normal rating.

Initial application of the engine will be to power helicopters, with the Sikorsky S-58 scheduled as the flight test vehicle.

Sikorsky S-58 helicopter is announced the first test plane for the T-58 engine.

The power-to-weight ratio of the T-58 is better than 3-to-1, compared to one hp per lb of engine weight delivered by conventional piston engines currently used to power helicopters.

According to GE, the engine's low specific fuel consumption and favorable power-to-weight ratio will improve helicopter mission performance in antisubmarine warfare, utility use, and light cargo operation.

A "free" turbine incorporated

Topics

It's a smaller world than we thought. New figures on our planet's size and shape indicate that its circumference is about ½-mile shorter than previously estimated. This fact may prove of value in tracing the man-made satellite that is to be launched next year.

• • •

Pen-sized gamma-radiation detector has been developed by Bendix Aviation Corp. for the Army. The dosimeter will measure up to 600 roentgens of gamma radiation from atomic or hydrogen bombs.

• • •

Successful test flight of the giant Douglas C-133A military transport is reported. This turboprop cargo plane could haul a 25-ton payload 3500 nautical miles or a 50-ton load up to 1000 miles.

• • •

Race tracks are safer than highways, according to Frank Mundy, veteran of 20 years of race and stunt driving. Reasons are that all cars on a track go in the same direction, each driver knows what the others are likely to do in most situations, and there are no "holiday leadfoot" drivers. Mr. Mundy travels to and from races by airplane.

• • •

News for engineers is presented to southern Californians in three 5-minute programs each week on radio station KFI. The programs feature news of significant technological advances in industry and education, personnel changes in engineering circles and news of technical societies.

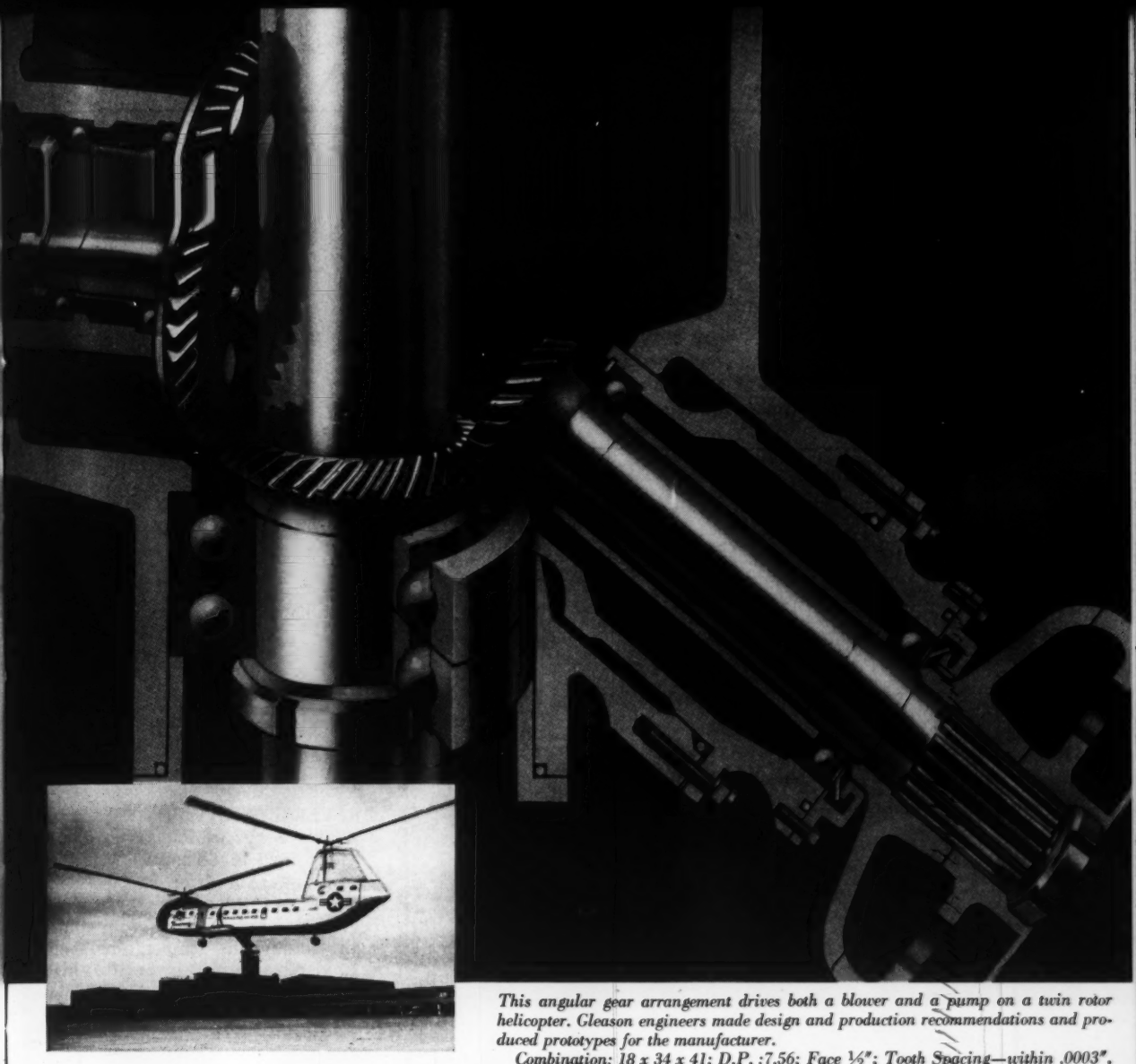
• • •

World's largest horizontal steel extrusion press is in use at the Metals Processing Div. of Curtiss-Wright Corp. The 12,000-ton press is the only one in the Air Force's heavy press program used for extruding steels and large titanium components.

• • •

Sanitary station wagon for use in transporting germ-free experimental animals will be built by Studebaker. Laboratory conditions will be duplicated in the vehicle, including a constant supply of temperature and humidity-controlled air. Air will be supplied to the animals' compartments through glass-fiber filters.

Facing Page—ITEM 508→



This angular gear arrangement drives both a blower and a pump on a twin rotor helicopter. Gleason engineers made design and production recommendations and produced prototypes for the manufacturer.
Combination: 18 x 34 x 41; D.P. :7.56; Face ½"; Tooth Spacing—within .0003".

You can solve your angular power transmission problems, too!

The designers of this gear unit achieve greater flexibility within a limited amount of space by placing the drive shafts at an angle and using one source of power to drive two auxiliary units.

Perhaps a similar gear drive would make your product designs more flexible. Such bevel gear drives permit a more compact design requiring less weight and the ability to carry higher loads.

Our engineers are ready to help you work out applications for bevel and hypoid gears—just as they helped the helicopter manufacturer with the design illustrated above.

We recommended the proper gear sizes and reviewed the mountings and lubrication for the drive. Then we produced and tested prototypes of the unit.

If you would like to discuss an application with one of our representatives, please write. You will also find these Gleason Technical Handbooks helpful: 20° Straight Bevel Gear System; Spiral Bevel Gear System; ZEROL Bevel System.

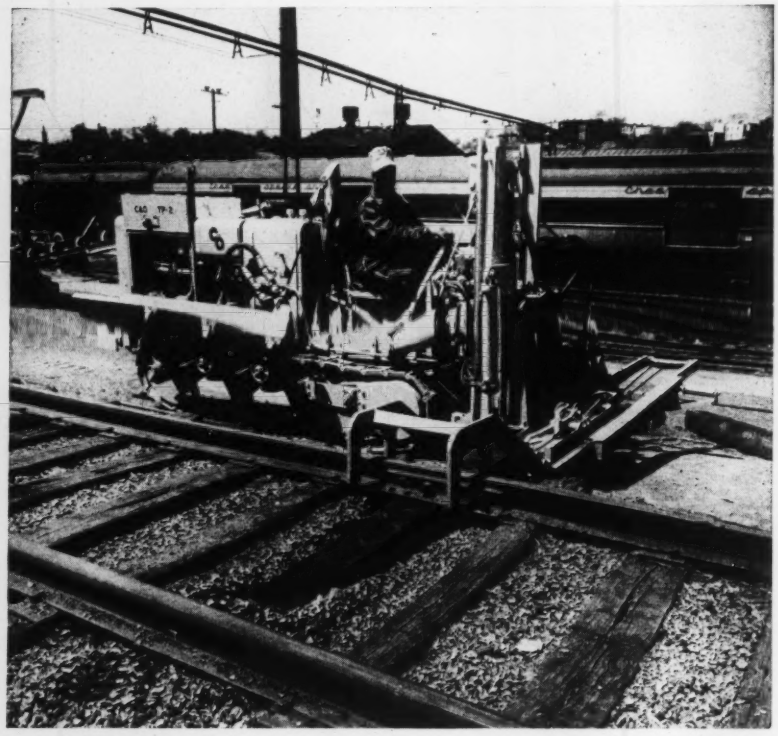
GLEASON WORKS

Builders of bevel gear machinery for over 90 years

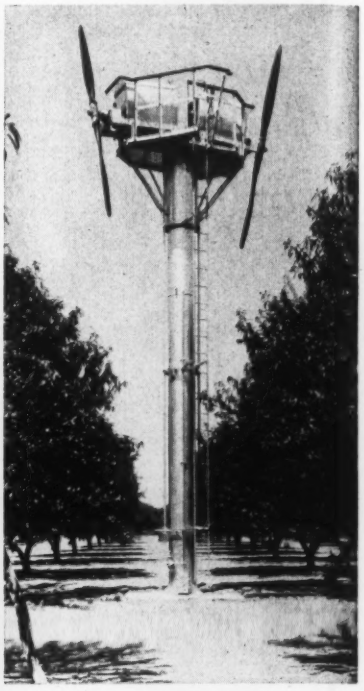
1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

in the T-58 engine introduces "fluid power transmission" to helicopter powerplants. The fluid is combustion gasses which, after passing through a two-stage turbine connected to the compressor, spins an unconnected turbine which turns the helicopter's rotors through a shaft. GE says this system offers a wide latitude of rotor speeds for a given power setting.

Other advantages claimed for the new engine are its ability to use a variety of low-cost aviation and gas-turbine fuels, like kerosene, and low starting-power requirement.



FAST CHANGE OF TIES is the job of this new machine recently demonstrated to stockholders of the Chesapeake and Ohio Railway. The tie machine removes and replaces wooden ties automatically without disturbing the adjacent roadbed or interfering with regular traffic.



REVERSE WINDMILL action is employed by gasoline-powered machines used in orchards to prevent crop damage by frost. Propellers direct warm upper air toward the ground, where it mixes with colder air, raising the temperature about 10 F. On this model, the 30-ft high platform rotates once every 9 minutes as the 12-ft propellers rotate about 880 rpm to move some 630,000 cfm of air. A 600-gal gasoline storage tank is contained inside the tower. The machine is operated and controlled from the ground. One of these National Frost Protection Co. wind machines protects as much citrus acreage as 100 smudge pots.

GM Executives Stress Research for Future

Problems, Prospects Noted At Tech Center Dedication

DETROIT, MICH.—President Harlow H. Curtice of General Motors, dedicating GM's new Technical Center, May 16, warned the nation that its survival may depend upon "more emphasis on basic research."

Speaking with President Eisenhower over an international closed circuit telecast, Mr. Curtice said stepped-up technological progress was essential to the continuance of American leadership in the free world.

Dr. Lawrence R. Hafstad, director of the GM Research Staff, seconded Mr. Curtice's warning. He said that the U.S. must meet the challenge to its technological supremacy by educating more engineers, scientists, economists and managers.

"Our choice is brutally clear," Dr. Hafstad said. "As a society, we can either learn mathematics and science—or Russian." He added, however, that he was "convinced that as a people we shall make the right choice."

Technical Center staffs, Dr. Hafstad said, are "continually broadening and expanding our programs in physics, chemistry, metallurgy, electronics, mathematics, and engineering. Thus today we are dedicating more than these marvelous facilities. We are dedicating ourselves to the never-ending task of advancing technology."

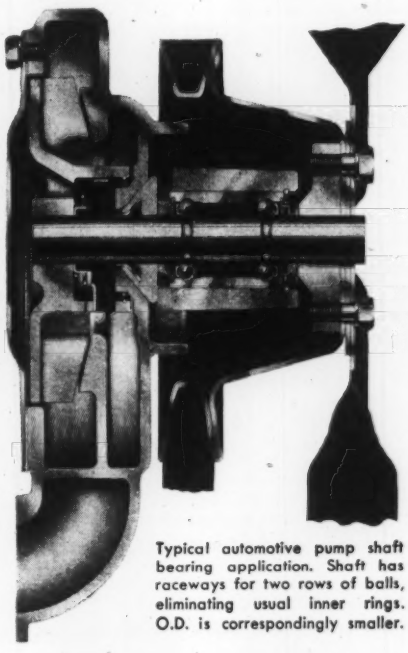
Dr. Hafstad said that GM research is particularly interested in materials and their uses. Not only are better metals and other materials needed for lower cost and improved performance in automobiles and other familiar products, but the newer fields of aeronautics, guided missiles and atomic energy demand a whole new category of materials to operate continuously at high temperatures.

According to Dr. Hafstad, con-

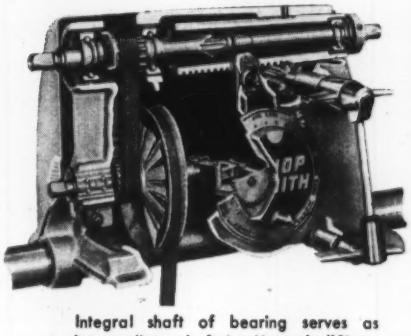
FACTS

about

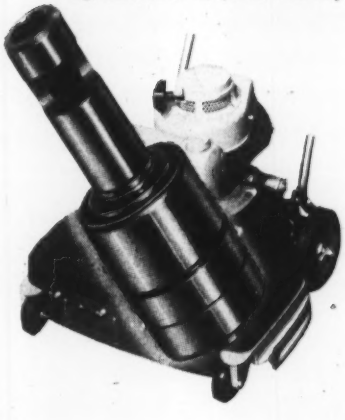
NEW DEPARTURE
BALL BEARINGS



Typical automotive pump shaft bearing application. Shaft has raceways for two rows of balls, eliminating usual inner rings. O.D. is correspondingly smaller.



Integral shaft of bearing serves as intermediate shaft in Magna's "Shopsmith". Assures fewer parts, easier machining, more accurate, quicker assembly.



For each McCulloch Mower, New Departure provides two pump shaft bearings with hollow shafts to permit vertical adjustments. Special heat treating gives full hardness at the raceways but adequate toughness in the shaft to withstand hard service.

FAN AND PUMP SHAFT BEARING IS ADAPTABLE TO MANY USES!

This sealed and "lubricated-for-life" bearing with integral shaft was originated by New Departure specifically to simplify automotive fan and water pump mounting. Since its inception, it has reduced bearing maintenance requirements to virtually zero in millions of car, truck and other engines.

Because of its unique design and ability to locate parts on its shaft against loads from any direction, designers find it a highly *versatile* bearing, adaptable to many other uses.

The manufacturer of a well-known power tool, which combines several tools in one compact unit, employs the pump shaft bearing as a complete intermediate shaft with pulleys on one end and a keyway for tool attachment on the other, with obvious design and performance advantages.

Another manufacturer produces a power mower in which two of these versatile NEW Departures with hollow shafts not only support the mower rotors, but permit vertical adjustment of the wheel spindles to regulate cutting height.

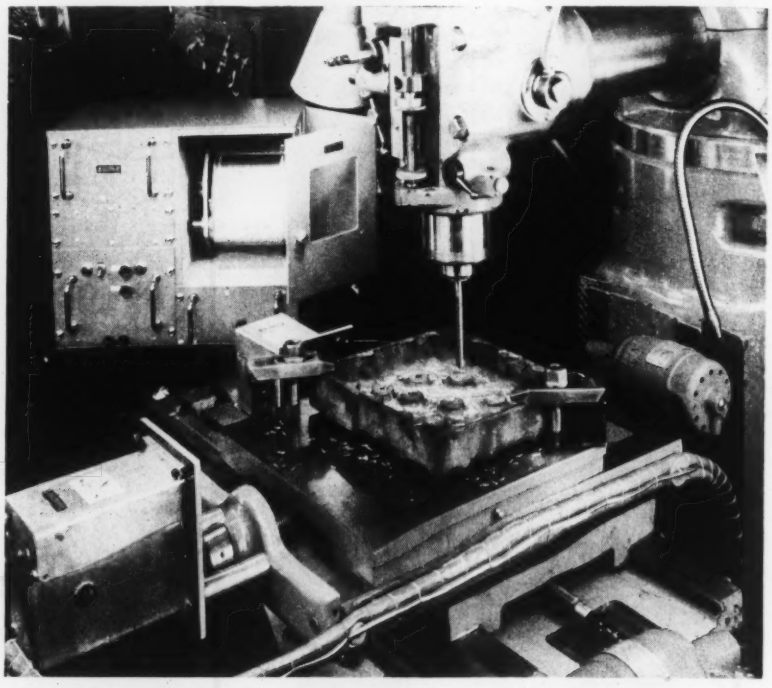
So here is another NEW Departure adaptable to many uses. New Departure engineers can show you what it and other ball bearings will do to improve your products.

FINE BALL BEARINGS MAKE GOOD MACHINES BETTER

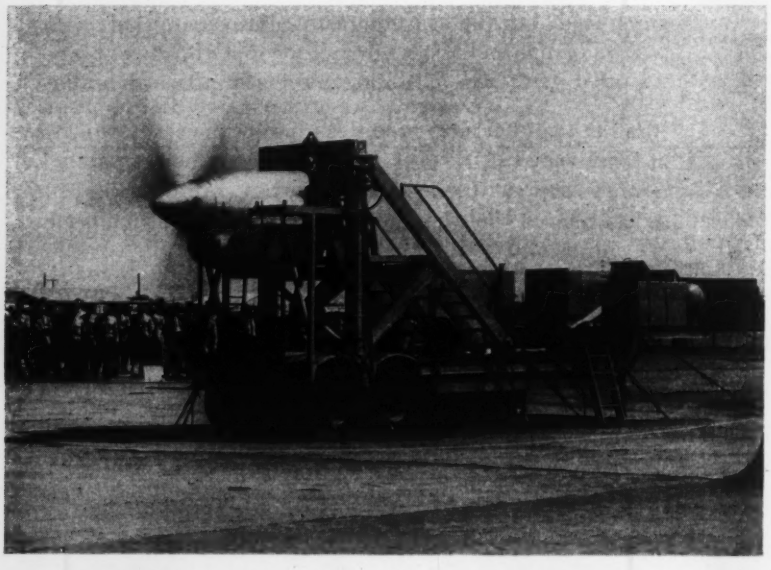
NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

cern over dwindling natural resources is in the main misplaced because research and technology will provide substitutes. Atomic energy promises to ease the problem of energy resources for "at expected rates of consumption the energy available from fissionable materials alone would take care of our needs for several centuries." In turn, low cost energy "more or less automatically" solves the materials supply problem. For example, low cost power might be used to produce fresh water—probably "the most critical material for the future"—from the sea.

"The technological chain reaction can provide for all our material wants" Dr. Hafstad said. "Wisely used, the by-product, leisure, can provide time for the study and solution of our social problems. Training for leadership in both technical and non-technical fields must be much improved. The foundation of scientific knowledge, both in the physical and biological fields, on which the entire physical structure of our current civilization rests, must be further strengthened and deepened by patient basic research."



LOW-COST AUTOMATIC POSITIONING TABLE is designed for repetitive runs in light manufacturing and small machine shops. Controlled by means of a Binotrol punched-tape system, this Barnes Engineering Co. unit controls a 10 by 10-in. table that is positioned in two axes to an accuracy of 0.001-in. It can be used with various machine tools to perform any of the usual machine-shop operations. The sequence of operations is permanently preserved on the tape, which can be filed for reuse. Future models will incorporate printed circuitry, reducing the size and weight of the present 60-lb control console by at least one-third.



TEST STAND FOR "HERCULES" is this semitrailer developed by Temco Aircraft Corp. It mounts the engines of the Lockheed C-130 troop and cargo transport, and has a sound-proof control house in which the engine instruments and controls of the C-130 are duplicated. Moved on the ground by any standard tractor, the 33-ft stand can be carried in the C-130 cargo hold.

New Developments Reported At Welding Society Meeting

BUFFALO, N. Y. — Papers dealing with new welding techniques, methods and equipment were presented at 21 sessions during the National Spring Meeting of the American Welding Society held May 7—11.

Papers delivered at the session on nuclear reactors revealed welding techniques developed to overcome a number of unusual problems and design requirements, such as welding 7000 ft of zirconium.

A new method of welding using the energy of ultrasonic vibrations was described. Solid-state bonding has been achieved with both similar and dissimilar metals by the introduction of elastic vibratory energy into the metals in the area to be joined. At present the process is applicable in joining foil

CUT

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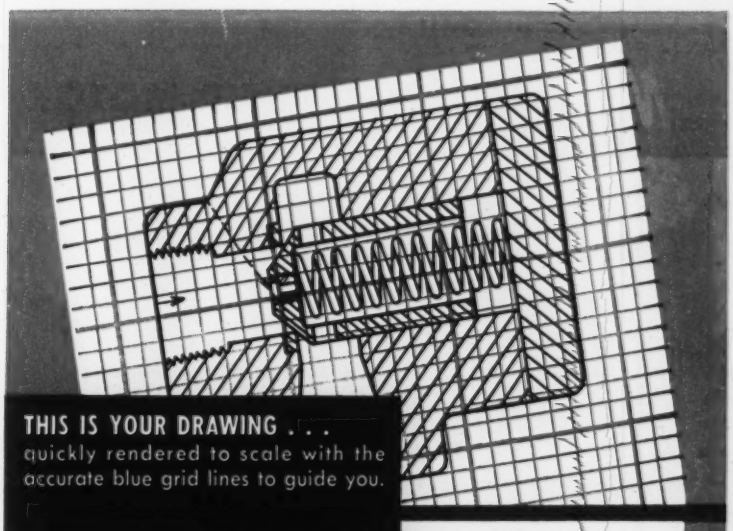

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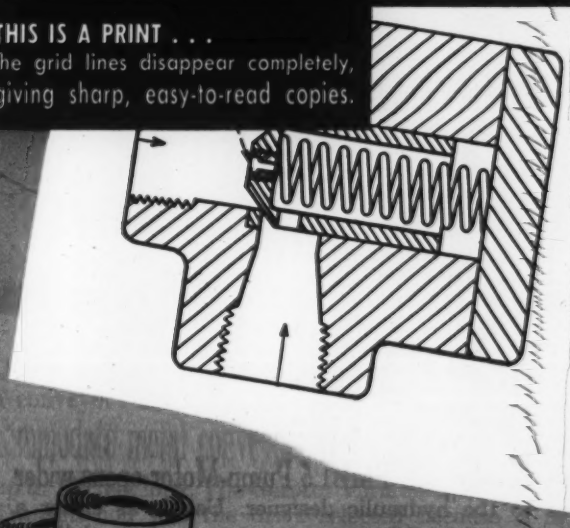

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—ITEM 510—

NEW GEROTOR PUMP-MOTOR

The new Gerotor MB-PMB1.5 Pump-Motor opens wider horizons to the hydraulic designer. Usable as either a pump or a motor, this compact power-package delivers a combination of features previously not found in standard designs.

- 2000 P.S.I.—5000 R.P.M.
- 115% Starting Torque
- 10—1 Speed Range, at
- Constant Torque
- Reversability
- Up to 3.4 H.P.
- High Efficiency, at
- Low Operating Cost.

Consult your nearest Gerotor distributor. Free literature available . . . *write:*

Progress Through Fluid Power by—

GEROTOR

MAY CORPORATION

MANUFACTURERS OF—

1537 MARYLAND AVENUE, BALTIMORE 3, MARYLAND

Hydraulic Pumps and Motors

Variable Speed Hydraulic Transmissions

PneuBin—Pneumatic Bin Evacuators

—ITEM 511—

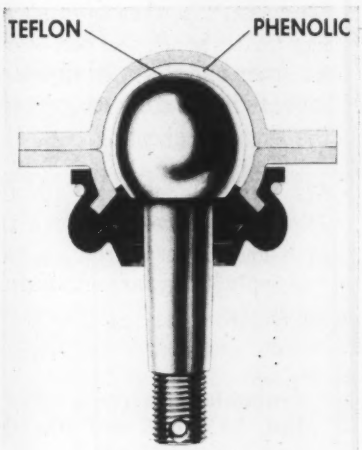
For More Information Circle Item Number on Yellow Card—page 19

and thin sheet to either very thin or massive members.

Other papers dealt with such subjects as new methods of control of rectifier type dc power sources designed for metal-arc, gas-shielded welding; a new method of fabricating and launching vehicular tunnel tubes; a new procedure for root-pass welding of stainless-steel pipe and plate using the inert-arc process; welding heavy sections of various aluminum alloys; and a new method of applying rotating bands to projectiles by means of welded overlays.

Auto Suspension Features No-Lube Joints

DETROIT, MICH.—A new automobile suspension joint that may eliminate the need for conventional lubrication in many types of bearings has been announced by the American Metal Products Co. Teflon plastic fiber has been used in a lining in a ball-and-socket joint



which may not require lubrication other than that provided by the normally slippery plastic.

The Teflon is double woven with a backing of nylon or cotton. The fabric is then laminated with cotton-reinforced phenolic resin and formed into a cup which lines the socket. Metal parts are coated with a special grease to prevent corrosion.

The joint is assembled and the preformed bearing is molded in place, assuring spherical contact between the ball stud and the

bearing. The joint is then sealed. Preliminary testing indicates that these bearings will last the lifetime of an automobile without lubrication or other maintenance.

The development is expected to have further application in hard-to-reach assemblies, on frictional parts in extreme temperatures, in corrosive chemical environments, and in bearings and joints subject to intermittent motion.

POWERFUL PYGMY, this aluminum-housed, oil-hydraulic pump is one of a series that includes models capable of developing more than 6 hp per pound of total weight. Designed for limited-life airborne applications, the miniature pumps are intended for use with system operating pressures up to 3000 psi. They are available with maximum rated power outputs up to 15.3 hp and with strokes up to 15 degrees.

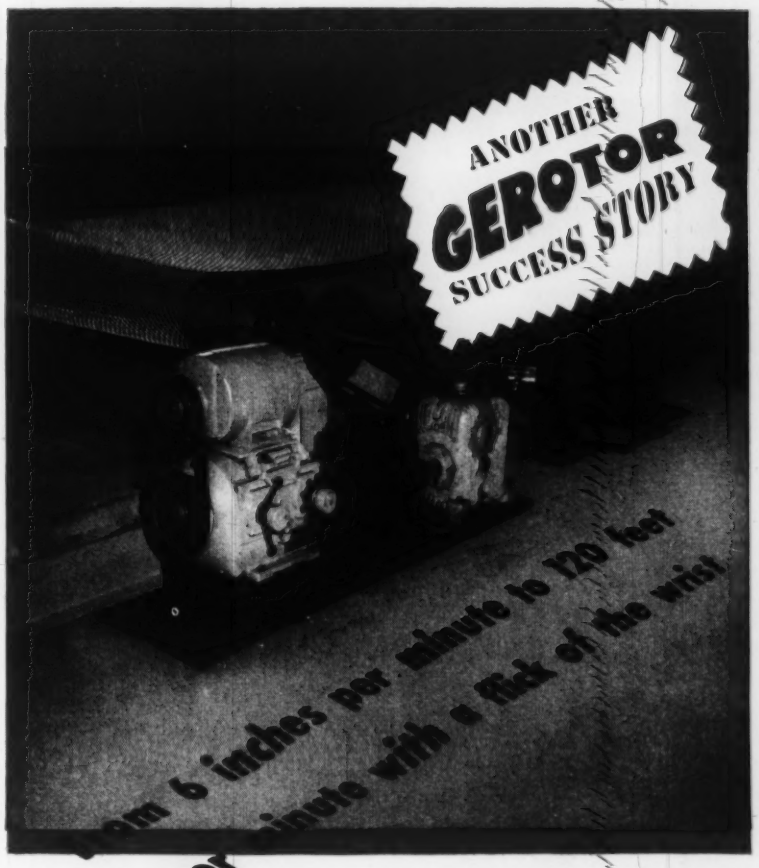
Develop Nickel Alloys For High-Temperature Use

NEW YORK, N. Y.—Two new high-temperature alloys suitable for use in aircraft and industrial gas turbines are announced by International Nickel Co.

Inconel 700 is an age-hardenable nickel-cobalt-chromium alloy containing approximately 50 per cent nickel and 30 per cent cobalt. It was developed to provide adequate strength for forged aircraft gas turbine blades at temperatures up to 1650 F.

Incoloy 901 nickel-iron-chromi-

(Continued on Page 22)



Our customer* needed a variable speed device to power a conveyor "assembly and test stand" which would accommodate metal conveyors up to 18 feet in width and up to 100 feet long. The Gerotor Variable Speed Hydraulic Transmission was the drive selected because it has a:

1. *wide enough speed range*
2. *smooth enough power flow*
3. *built-in overload protection*
4. *compact size, and*
5. *low maintenance factor.*

The installation engineered by Gerotor allows the operator to run the conveyor at speeds *from a smooth creep condition of 6 inches per minute to 120 feet per minute.* The added versatility of being able to adjust the torque output at any speed was theirs at NO EXTRA COST, and the conveyor can be stopped or reversed by means of the Gerotor Transmission.

If you have a hydraulic transmission problem . . . bring it to Gerotor. Free literature available . . . *write:*

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Progress Through Fluid Power by—

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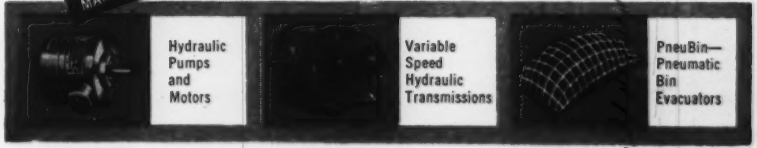

—ITEM 512—

ROTARY SEAL

SPECIALIZED SEAL ENGINEERING

is solving some long-time headaches in developing TRACK-ROLLER SEALS FOR CRAWLER-TYPE TRACTORS

No simple task, this—to get the bugs out of an old bugbear in the heavy-duty machinery field. Months and months of effort—guided by years and years of specialized experience—have gone into the development of the track-roller Seal illustrated. But it solves the old problems of sealing dirt out, sealing lubricants in, with a completely self-contained unit.

This Seal, specially developed for a leading Mid-West manufacturer of machinery, exemplifies the skill and patience of ROTARY SEAL engineering. That's our business—solving hard Shaft Sealing problems where production quantities of Seals are involved, by applying the basic ROTARY SEAL principles which opened the way to successful mechanical Shaft Sealing when this company introduced them years ago.

Major assignments for important Seal developments are keeping us mighty busy at present; but if special difficulties are besetting your development progress, and production quantities of Seals are involved, we'll be glad to help if we can.

THE ROTARY SEAL Division of MUSKEGON PISTON RING CO.

mechanical seals for rotating shafts

Shaft-Sealing with Certainty

2022 NORTH LARRABEE STREET
CHICAGO 14, ILLINOIS, U.S.A.

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418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
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420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
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422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
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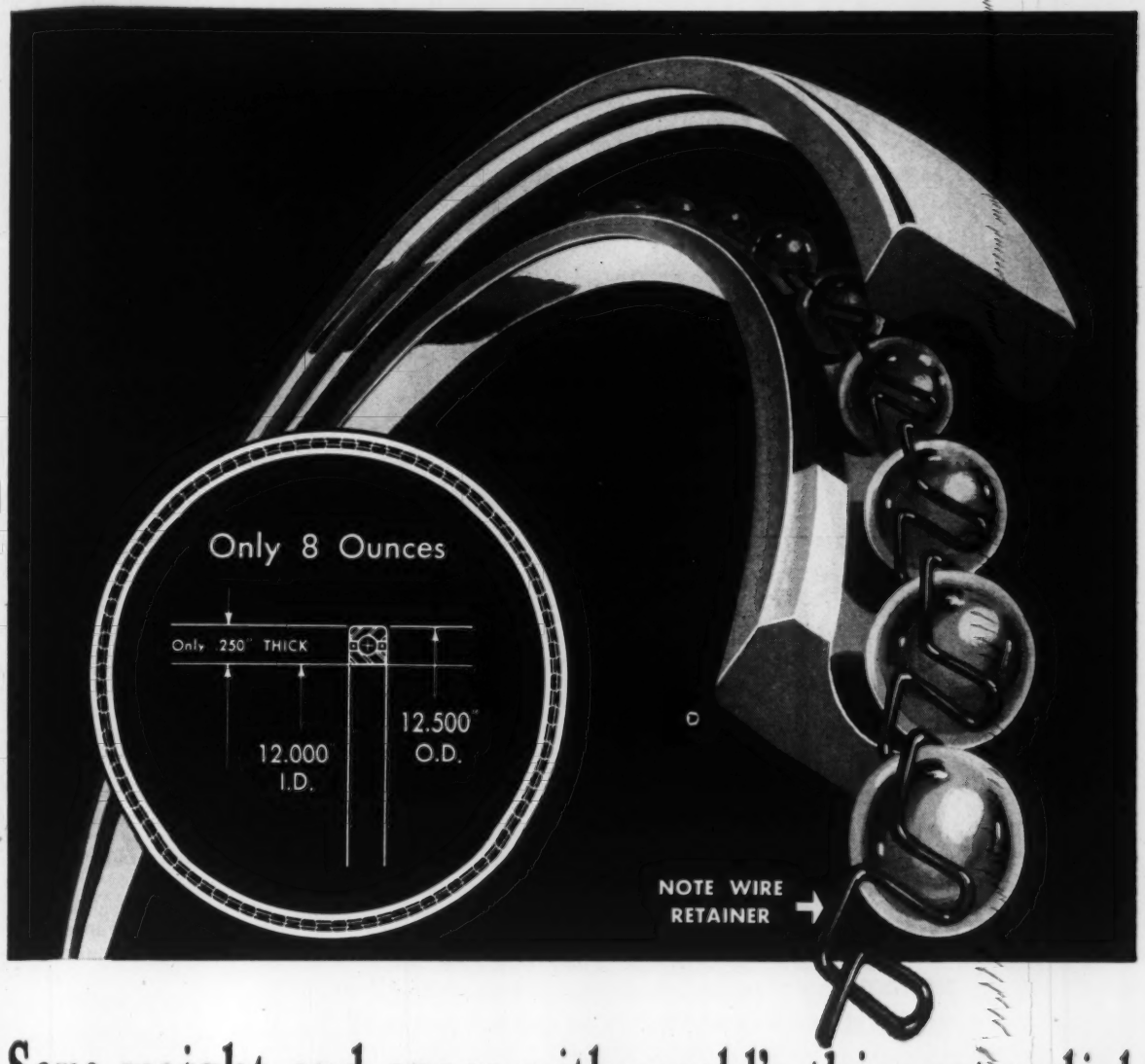


Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light in weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

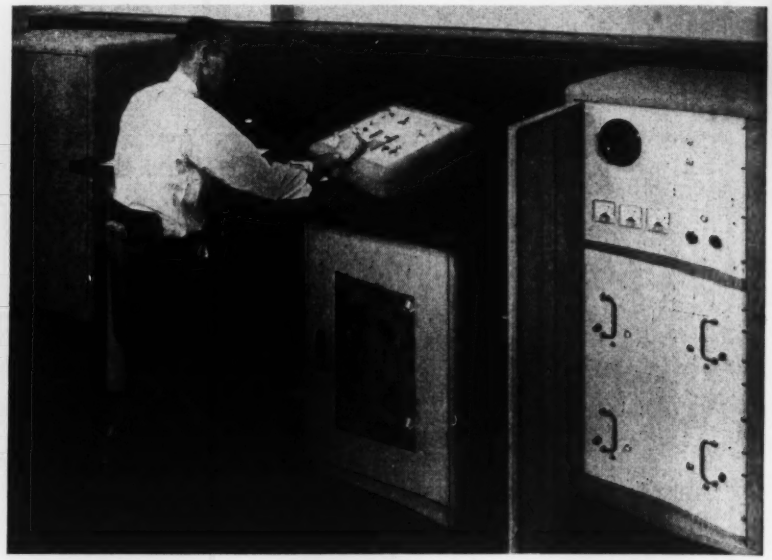
THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-561

All types of ball and roller bearings — 4" bore to 120" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Ball Radial • Ball Thrust Bearings



MAGNETIC-TAPE TOOL CONTROLLER is the new "Digimatic" developed by Electronic Control Systems Inc. The machine consists of a planning desk and a machine control unit. Dimensions of a finished part are entered on tape through keyboard like that of adding machine. Tape directs a milling machine in making cams to accuracy of 0.001 in. and finer, if needed. "Digimatic" can control several machines on one job simultaneously.

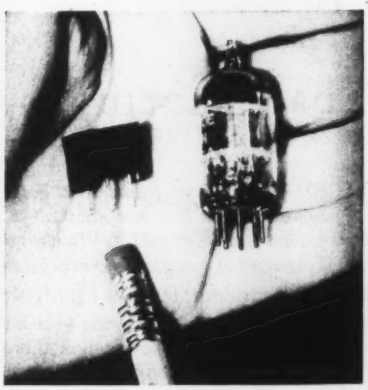
(*Continued from Page* 15)

um alloy is suitable for aircraft and industrial gas turbine components requiring high creep and rupture strength in the temperature range of 1000 to 1400 F. This material has a low coefficient of thermal expansion. It contains approximately 40 per cent nickel and can be joined to ferritic alloy steels without special provision for thermal expansion.

The Investment Casting Institute will sponsor a six-day intensive course in investment casting at the University of Michigan, September 10—15. Forty persons from the Institute's member companies are enrolled in the course. Lectures and laboratory experiments will deal with such subjects as investment materials; gating and risering (mold design); melting, refining, and degassing; and properties of heat-resistant alloys. A seminar will cover precision casting methods, methods of instrumentation, furnace design, furnace atmospheres and desirable thermal cycles. The Institute is planning an advanced course in investment casting at Massachusetts Institute of Technology in 1957.

Miniature Rectifier Replaces Electronic Tube

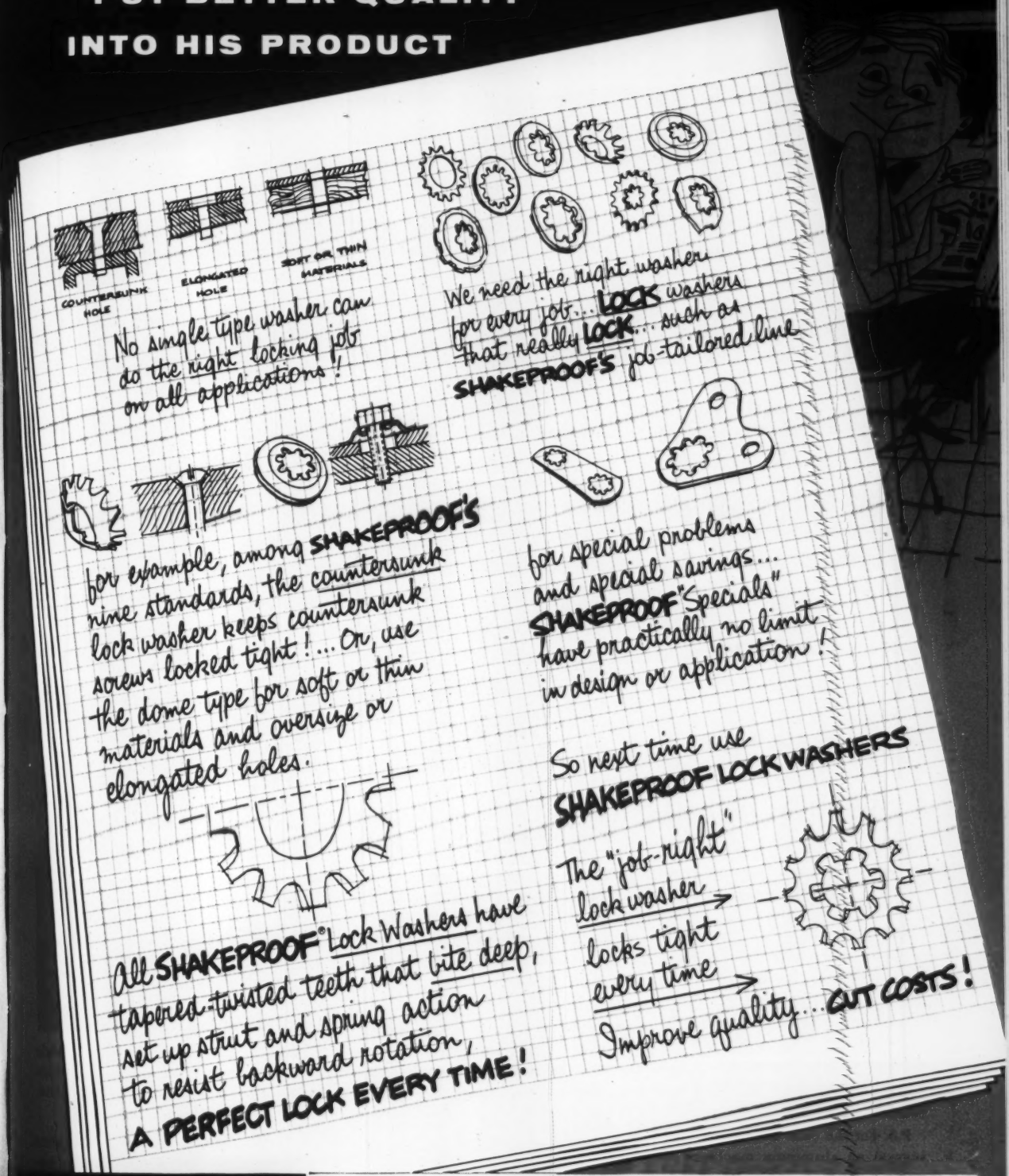
SCHENECTADY, N. Y.—A tiny twin-diode rectifier is announced by General Electric Co. for use as a horizontal phase detector to replace a tube used in television sets. It costs only about half as much,



lasts many times longer, and is more resistant to breakage than the tube it replaces. The rectifier withstands prolonged exposure at 90 per cent humidity and can operate at high ambient temperatures. It has rugged tinned leads for use in printed circuits or other automatic assembly operations.

Electrical characteristics include

HOW A YOUNG DESIGN ENGINEER PUT BETTER QUALITY INTO HIS PRODUCT



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DIVISION OF ILLINOIS TOOL WORKS
World's Broadest Line of Mass-Assembly Fastenings

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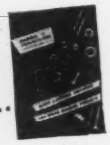
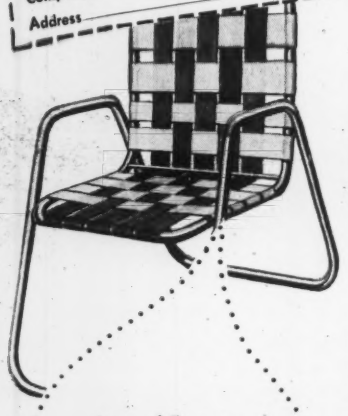


ALUMINUM COMPANY
OF AMERICA
2244-F Alcoa Bldg., Pittsburgh 19, Pa.
Gentlemen:
Please send complete specification data and samples of your aluminum fasteners.
Name
Title
Company
Address



An Alcoa
Aluminum
Fastener
should be
used here!

It's an aluminum chair assembly, worth the lasting strength of Alcoa® Aluminum Fasteners. You avoid galvanic and atmospheric corrosion. You get perfect color match; you get the very highest quality product. Your local Alcoa distributor has a complete stock.

P.S. For this chair assembly, we suggest an aluminum machine screw, washer and nut from Alcoa's complete line of aluminum fasteners.

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

YOUR GUIDE TO
THE BEST IN
ALUMINUM VALUE

—ITEM 517—

minimum forward current of 0.5-ma dc at 2 v, and maximum reverse current of 25 microamp at −20 v. The characteristic capacitance per section is approximately 50 micro-micro-farads, with negligible unbalance.

G-E engineers believe applications other than use in TV sets will be found for the new rectifier, and that it will have an effect on electronic circuit design.

Rolling over blocks and planks scattered in its path, this plane demonstrates the ability of Goodyear Terra-Tires to maneuver on rough ground.

Fat Tires Make Light Work of Rough Ground

Plane Lands 'Most Anywhere With Oversize Gear

AKRON, O. — A light plane, equipped with what are believed to be the lowest pressure pneumatic tires ever mounted on aircraft, has been successfully taken off and landed on both sod and concrete at Akron Municipal Airport.

Tests were conducted recently by the Aviation Products Div. of Goodyear Tire & Rubber Co. on a Stinson Voyager equipped with two barrel-shaped Terra-Tires. The oversize tires were designed for planes which must risk the hazards of landings and take-offs in unimproved areas.

The undercarriage of the Stinson was rebuilt to accommodate two 24-in. wide flat-sided low-pressure tires, complete with brakes. Tire pressure during the tests varied from 3 to 8 psi.

Aviation usage of Terra-Tires is being explored by taking the Stinson in and out of marginal landing areas. Future evaluation flights are expected to confirm the belief that airplanes equipped with Terra-Tires can operate in and out of plowed fields, clearings and other rough ground not cluttered with major obstacles. The tires are also expected to be useful on ice and snow-covered areas, and in marshy and sandy regions.

Goodyear Terra-Tires 24 in. wide are compared with 6 in. wide conventional tires for the same plane.

A guided-missile system will be developed and produced in a new $40 million facility to be built by

YOU'LL FIND G. S. GEARING IN TOP QUALITY PRODUCTS LIKE THESE . . .

Adding Machines • Aircraft Carburetors & Fuel Metering Systems • Aircraft Instruments and Radios • Automatic Musical Instruments • Business Machines • Check Signing & Protecting Machines • Clippers for Barbers, Animal Shearing & Hedge Trimming • Cloth Cutting Machines • Coin Changers & Counters • Communication Equipment • Electric Fans • Electric Motors • Floor Polishers, Sanders, Scrubbers, Sweepers • Food & Drink Mixers, Blenders • Home Appliances • Lawn Sprinklers • Machine Tools • Meat Tenderizers, Grinders, Slicers • Military Equipment • Motion Picture Cameras & Projectors • Outboard Motors • Pneumatic Production Tools • Radio & Radar Tuning Assemblies • Radio Anti-backlash Gears • Record Changers • Sewing Machines • Steel Strap Stretchers • Step Switches • Tapping, Drilling & Threading Equipment • Telephone Dials • Television Sets • Thermostatic Controls • Typewriters • Vending Machines • Washing Machines.

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WORM GEARING • RACKS • THREAD GRINDING

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ELECTRIC TOOLS GIVE EXTRA YEARS OF PERFECT SERVICE WITH G. S. SMALL GEARING

More and more makers of fine electric tools are turning to G. S. for Small Gearing. They quickly discover improved performance, in both product and production. Mechanisms run smoother, quieter, longer, *more dependably*. Assembly lines roll consistently, without painful headaches and interruptions. G. S. Small Gearing has been brought to its present perfection through more than 40 years of specialization. Men, machines, and exclusive methods are developed to a degree of UNIFORM accuracy beyond anything you ever thought possible. Write or call us now for *your* Small Gearing needs. We mass produce hundreds or thousands . . from 8 dp to 96 dp . . quickly, efficiently, at modest cost.

SEND FOR FREE *6-page Small Gearing Guide. It describes 80 types and applications. Contains useful charts . . a valuable aid to anyone interested in Small Gearing. Use company letterhead, please. No obligation, of course. Write today!*

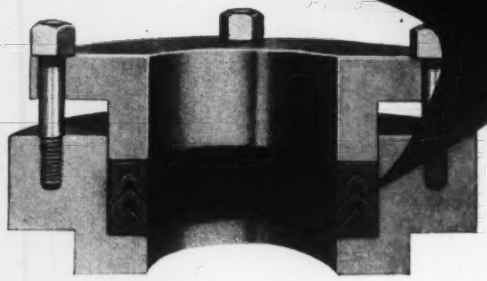
FRACTIONAL HORSEPOWER GEARING

40 Years of Specializing in Small Gearing!

—ITEM 518—

ONE OF THE GARLOCK 2,000

SHALLOW STUFFING BOXES NEED THIS KIND OF "GRIP"



GARLOCK
431 CHEVRON* PACKING

tightens as pressure increases, eases off as pressure decreases, assuring no-leak sealing and minimum friction on rams, plungers, reciprocating rods, etc.

LOOK AT THESE SERVICE REPORTS:

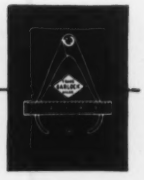
- On hydraulic press with 40" dia. ram, operating at 6000 psi pressure, .006" clearance between ram and gland, GARLOCK 431 CHEVRON size 40" x 41½" by only 2" deep gave 14 years service.
- On hydraulically operated clutches with ¾" cylinder, 500 psi pressure, ¾" travel, operating intermittently. Neither leather cups nor "O" rings worked well. Now packed with GARLOCK 431 CHEVRON ⅜" x ¾" x 17/32" deep. Result: smooth, positive sealing.

And remember, 431 CHEVRON Packing is only one of "the famous GARLOCK 2,000" . . . two thousand different styles of packings, gaskets, and seals to meet *all* your needs. It's the *only* complete line . . . it's one reason you get unbiased recommendations from your GARLOCK representative. Call him today or write for Folder AD-115.

*Registered Trademark

THE GARLOCK PACKING COMPANY,
Palmyra, New York
For Prompt Service, *contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.*

GARLOCK

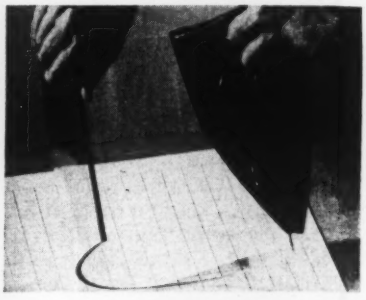


Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

—ITEM 519—
For More Information Circle Item Number on Yellow Card—page 19

News Roundup

Convair Div. of General Dynamics Corp. in Sorrento, Calif. The site involves 280 acres of land, and buildings will occupy approximately 1,000,000 sq ft of floor space.



OPTICAL PROPERTIES of acrylic sheet material are retained during forming through the use of a protective coating. Smooth, pliable Optijel covers the sheet, becoming an integral part of it, and absorbs any foreign matter that is between itself and the sheet or die. After forming of the acrylic part, the coating is peeled off, leaving a smooth surface. The Optipeel process was developed by Plastic Age Sales Inc.

Inexpensive Synthetic Cuts Hard Materials

ALLENTOWN, PA.—A new synthetic material, harder than any known substance except diamond, can be used to cut a variety of metals at a wide range of speeds and feeds. It is similar in its properties to sapphire, but will cut the natural gem stone. The synthetic is highly resistant to chipping at the cutting edge.

Called Sintox and made by Sintox Inc., the material is produced by intermolecular fusion by a technique similar to that used in making synthetic diamonds. Materials used in producing Sintox are so inexpensive that tools made from it can economically be discarded rather than resharpened when they become worn.

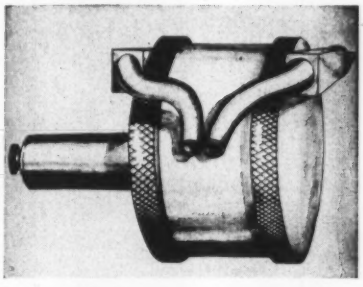
The new synthetic will cut metals ranging from soft brass to heat-treated alloy steel, up to 63 C Rockwell, at any industrially practicable speed. Cuts as fine as 0.0002-in. deep or as wide as the tool's cutting face can be made.

Return of "Nickel Beer" Made Possible by Automation

Vending Machine Uses Positive-Displacement Valve

PUNXSUTAWNEY, Pa. — A new valve made by the Punxsutawney Co. for accurately measuring and controlling flow of liquid or gas is claimed by the manufacturer to be ideal for automatic dispensing. It is used in the first coin-operated vending machine that dispenses draft beer.

A cylinder and piston arrangement provides measuring accuracy in this positive-displacement valve, and flow is controlled by a hydraulic brake. A wide variety of measuring or dispensing facilities in any predetermined volume is possible. The valve permits measurement and dispensing from two sources to one common discharge, from two sources to two discharges, or from one source to one discharge.



Positive-displacement valve combines characteristics of a standard four-way valve with accurate premeasurement and control of flow.

Glass-Reinforced Plastic Filters Ultraviolet Rays

AKRON, O.—A new material made of plastic reinforced glass fibers and special ingredients has been developed by Firestone. It filters the ultraviolet from sunlight and permits up to 50 per cent of visible light to pass through. Firestone uses the material for windows in rubber storage warehouses.

Color pigments and other ingredients can be added in manu-

CLUTCHES FOR POWER CONTROLS DESIGNS

THE NEW HILLIARD-TWIFLEX

Centrifugal Coupling

AUTOMATIC smooth starting with protection against overload shock.

FLEXIBLE in all directions without any loose joints.

ADJUSTABLE to exactly suit the operating conditions.

SIMPLE CONSTRUCTION and easy assembly even in blind installations.

Hilliard-Twiflex Centrifugal Couplings provide automatic shockless power transmission and trouble-free operation even under relatively great misalignment without any lubrication whatsoever.

They are being used very successfully in the drive of compressors—agricultural sprayers—mixers—conveyors—generators—fans and blowers—pumps—hammer mills—crushers—winches and hoists—refrigeration equipment—textile machinery—and wherever smooth, efficient operation is needed.

Tests in a variety of installations for over five years prove the Twiflex is the practical solution to many drive problems.

WRITE TODAY FOR BULLETIN CE-3 WITH COMPLETE INFORMATION.

★

• OTHER HILLIARD CLUTCHES •

SINGLE REVOLUTION CLUTCHES for automatic accurate control—electrical or mechanical—of intermittent motion, indexing, cycling and cut-off. Ask for Bulletin 239.

OVER-RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet or backstop action. Ask for Bulletin 231.

SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands. Ask for Bulletin 300.

★ CONSIDER AUTOMATION-INVESTIGATE THESE PRODUCTS

THE HILLIARD Corporation

MANUFACTURING CLUTCHES FOR OVER 50 YEARS

103 West Fourth St.
Elmira, New York

IN CANADA: UPTON • BRADEEN • JAMES, LTD.

—ITEM 520—

facturing the plastic. Panes have been made in light-fast colors. Firestone says that windows tinted a certain shade of light green do not produce a greenish cast in building interiors.

The plastic-glass is also claimed almost unbreakable, easier to clean than ordinary glass and resistant to chemicals, smoke and smog.

BIGGEST BOLTMAKER is being made for the Cleveland Cap Screw Co. by National Machinery Co. Claimed to be the world's largest cold-forging machine, the Boltmaker will process 1 7/16 in. steel rod into 1¼ in. cap screws, 10 in. long, at rates up to 40 per minute. The screws will weigh 5 lb each and the machine will consume a ton of steel every 10 minutes.

New President of NSPE Elected

WASHINGTON, D. C. — Robert J. Rhinehart, Pine Bluff, Arkansas, has been elected president of the National Society of Professional Engineers. He will assume his new duties July 1. Mr. Rhinehart is division superintendent for the Arkansas Power & Light Co.

Chemical milling of steel and titanium is being done on a pilot plant scale by Turco Products Inc. A joint effort of Turco and North American Aviation Inc., the pilot plant is being used to develop new techniques in chemical milling, to prepare prototype parts for prospective users of the process, and to train operators of the process.

Meetings

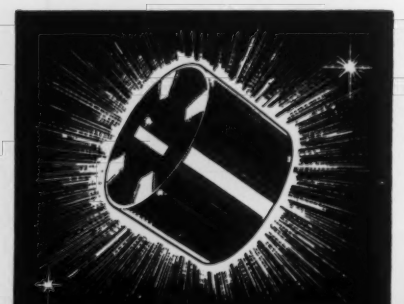
AND EXPOSITIONS

June 25-29—

American Institute of Electrical Engineers. Combined Summer and Pacific general meeting to be held at the Fairmont Hotel, San Francisco. Additional information can be obtained from institute headquarters, 33 W. 39th St., New York 18, N. Y.

June 25-29—

American Society for Engineering Education. Annual meeting to be held at Iowa State College, Ames, Iowa. W. Leighton Collins, University of Illinois, Urbana, Ill.,



GET THE FACTS ON

GRAPHALLOY

LONG WEARING
LOW FRICTION

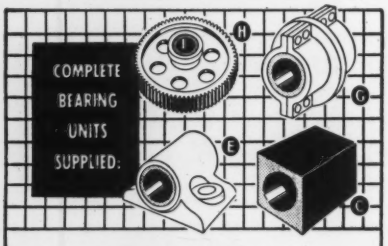
UNIQUE (OIL-FREE)

SELF-LUBRICATING
BUSHINGS

EXCELLENT DURABILITY • CONSTANT COEFFICIENT OF FRICTION • APPLICABLE OVER A WIDE TEMPERATURE RANGE (−450° to +700°F.)

OPERATE DRY, OR AT HIGH SPEEDS SUBMERGED IN WATER, GASOLINE OR LIQUID GASES • NON-CONTAMINATING IN FOODSTUFFS • EXCELLENT FOR CURRENT-CARRYING BEARINGS

GRAPHALLOY is widely used for self-lubricating piston rings, seal rings, thrust and friction washers, pump vanes.



BRUSHES • CONTACTS

GRAPHALLOY has high-performance electrical properties: *low electrical noise, low and constant contact drop, high current density, minimum wear!*

Brush Holders and Assemblies, Coin Silver Slip Rings and Assemblies available.

USE OUR 40 YEARS OF DESIGN EXPERIENCE!

GRAPHITE METALLIZING CORPORATION

1045 Nepperhan Ave. • YONKERS, NEW YORK

☐ Please send data on Graphalloy Oil-Free BUSHINGS.

☐ Send data on BRUSHES and CONTACTS.

NAME & TITLE

COMPANY

STREET

CITY ZONE STATE

—ITEM 521—

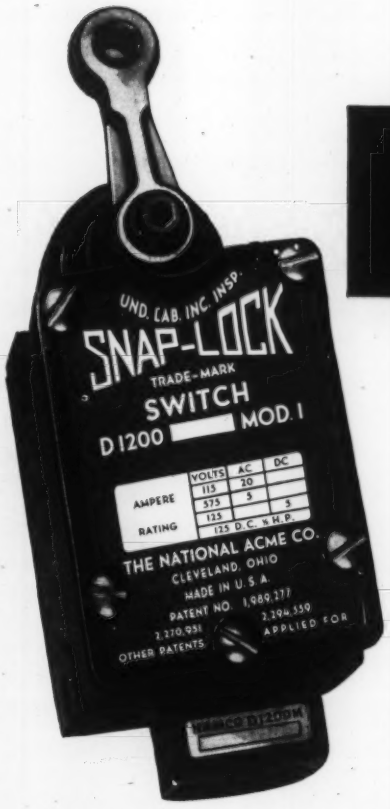
NATIONAL ACME

SNAP-LOCK

TRADE MARK

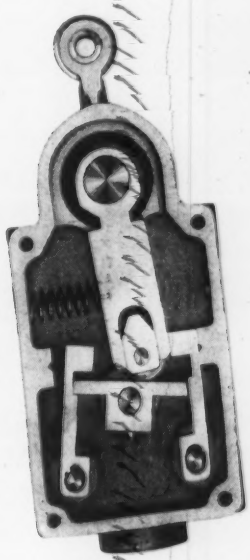
THE ORIGINAL

SNAP-ACTION LOCKING SWITCH



SNAP-LOCK LIMIT SWITCHES. Made in both single-pole and double-pole series, and in four types: Standard, Short Travel, Neutral Position and Push Lever. With the exception of the Push Lever Switch, all are adaptable to special enclosures for hazardous location service and may be used with various styles of operating levers. For AC or DC service.

ELECTRICAL SIDE



MECHANICAL SIDE

Electrical and mechanical sides are separated by a wall within a sturdy die-cast housing which is fully insulated and is oil and dust resistant. Can also be furnished water and oil-tight.

PROVED . . . by millions of contacts

SNAP-LOCK Push Button Control Station Switches

Made up of small SNAP-LOCK switches, with separate enclosures for electrical and mechanical sides. Adaptable to any number of units and in any arrangements of buttons, in flush or surface mounted types. For AC or DC service.

SNAP-LOCK Motor Starter Switches

SNAP-LOCK Motor Starter switches are designed for 3-phase motors to 7½ HP on AC ½ HP on DC.

All National Acme Switches—Limit Switches, Push-Button Control Station Switches and Motor Starter Switches—employ the same dependable, basic **SNAP-LOCK** design. As illustrated above, the snap-action locking mechanism is simplicity itself—fool-proof, accessible, and long-lived. The double-throw contact lever is connected directly by shaft with the latch bar on the mechanical side and carries self-wiping coin silver contact points to insure quick action make and break, with maximum wear resistance.

Send for Bulletin EM-51, or let us discuss your design problems with you.

ELECTRICAL MANUFACTURING DIVISION

National Acme

The National Acme Company • 188 East 131st Street, Cleveland 8, Ohio

is secretary of the society.

Aug. 6-8—

Society of Automotive Engineers Inc. National West Coast Meeting to be held at the Mark Hopkins Hotel, San Francisco. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Aug. 21-24—

Western Electronic Show and Convention. Show headquarters, Pan Pacific Auditorium; Convention headquarters, the Ambassador Hotel, Los Angeles, Co-sponsored by the West Coast Electronic Manufacturers' Association and the Los Angeles and San Francisco sections representing the Seventh Region of the Institute of Radio Engineers. Additional information can be obtained from Wescon, 344 N. La Brea Ave., Los Angeles 36, Calif.

Sept. 7-9—

Metal Powder Association. Fall Meeting to be held at the Homestead, Hot Springs, Va. Additional information can be obtained from association headquarters, 420 Lexington Ave., New York 17, N. Y.

Sept. 10-12—

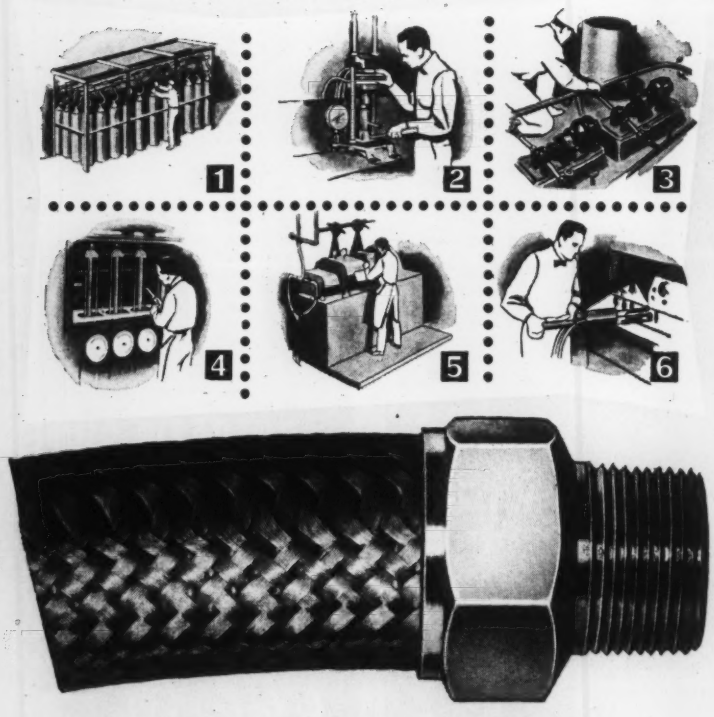
American Society of Mechanical Engineers. Fall Meeting to be held at the Cosmopolitan Hotel, Denver. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 10-13—

Society of Automotive Engineers. National Tractor Meeting and Production Forum to be held at Hotel Schroeder, Milwaukee. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 11-13—

American Die Casting Institute. Annual Meeting to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from institute headquarters, 366 Madison Ave., New York 17, N. Y.



Here, there, everywhere in the plant... you find money-saving uses for Titeflex flexible metal hose

Here's the hose that licks critical corrosion, temperature, vibration and pressure problems in conveying gases, liquids, lubricants.

Universal applications. All-metal construction. Braided or unbraided. Alloys to meet *every* need.

Investigate. Check the drawings (above) for ideas in the use of Titeflex Flexible Metal Hose in your plant. Use coupon to obtain information about this versatile and durable all-metal hose.

1 Fire extinguisher systems
2 Plastic presses
3 Food processing equipment
4 Electronic degassing equipment
5 Machine tools
6 High frequency conductors

Titeflex

TITEFLEX, INC. Industrial Products Division
508 Hendee Street, Springfield 4, Mass.

Please send your free Titeflex Flexible Hose Catalog without obligating us.

Name_____ Title_____

Firm_____

Address_____

City_____ Zone_____ State_____

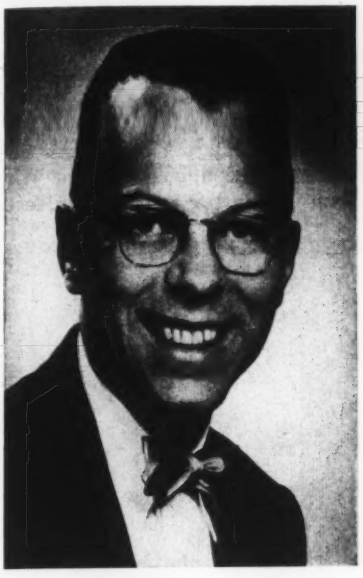
TITEFLEX FLEXIBLE METAL HOSE licks corrosion, temperature, vibration, pressures in all industrial operations

—ITEM 523—
For More Information Circle Item Number on Yellow Card—page 19

MEN

OF MACHINES

Robert G. Keller recently was appointed chief engineer for the Machine Div. of Lewis Welding & Engineering Corp., Cleveland. Mr. Keller will be in charge of design



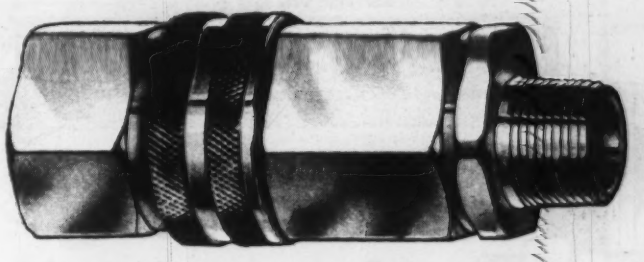
Robert G. Keller

and development work on the company's proprietary machines, special machinery and automation equipment. He will be assisted by **Johan Muller,** chief development engineer of the division.

John H. Carter has been appointed associate research director of Lockheed's Missile Systems division at Van Nuys, Calif. He was formerly chief of the Air Force's guided missile section at Wright Air Development Center.

E. H. Titchener & Co., Binghamton, N. Y., has promoted **Edward T. Wayne,** design engineer, to vice president and director of engineering.

Frank W. Godsey Jr. and **W. Waits Smith** have been elected vice presidents of Westinghouse Electric Corp., Pittsburgh. Mr. Godsey has been manager of the Electronics X-Ray and Air Arm divisions in Baltimore since 1951. He joined



From raw materials to finished products—

Titeflex Quick-Seal Couplings

"make connections"... fast!

Quick-Seal couplings are absolutely leakproof. Couple and uncouple in just one second . . . *without* tools. And Quick-Seal couplings keep the lifelines of your operation open and flexible—allow *free* flow of liquids, gases, lubricants in any direction. Suitable for *all* industrial applications.

Check the drawings (above) for typical applications. Use it as a guide to uncover new profitable uses for Quick-Seal couplings in your plant.

1 High pressure testing
2 Diesel engine refueling lines
3 Furnace cooling water lines
4 Tank car unloading
5 Mass production testing
6 Rolling mill hydraulic lines

Titeflex

TITEFLEX, INC. Industrial Products Division
508 Hendee Street, Springfield 4, Mass.
Please mail your free Quick-Seal Coupling Catalog . . . without obligating us.

Name_____ Title_____

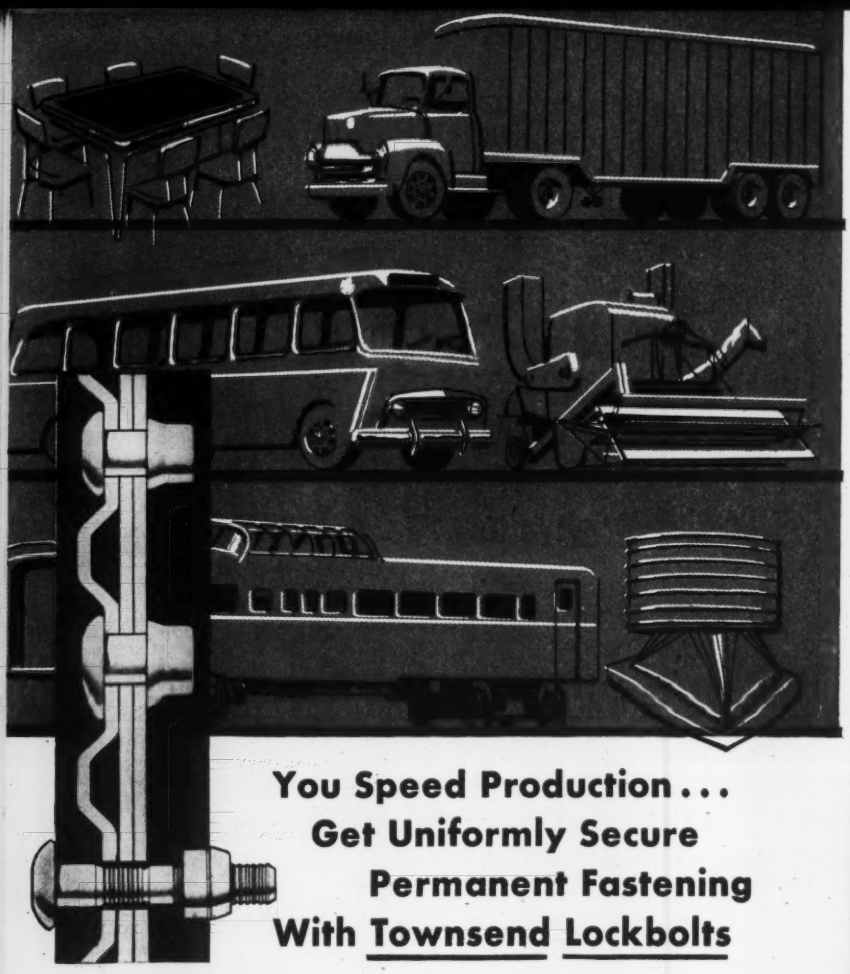
Firm_____

Address_____

City_____ Zone_____ State_____

Titeflex Quick-Seal Couplings • *leakproof at all operating pressures, in every application*

—ITEM 524—



You Speed Production . . . Get Uniformly Secure Permanent Fastening With Townsend Lockbolts

The Townsend lockbolt provides a quick method of producing uniformly secure fastenings that cannot loosen even under extreme vibration or shock conditions. They combine the advantages of riveting and bolting—eliminate the disadvantages.

Typical users are manufacturers of railroad cars, highway trucks and trailers, buses, farm equipment, industrial ventilators, and furniture. They find that the use of Townsend lockbolts gives them an opportunity to improve their products—reduce unit costs.

These benefits are possible for several reasons. By use of Townsend lockbolts, fewer and less skilled workers can complete an assembly faster than by other methods because the setting action does not depend upon the skill of the operator. The clamping action, or tensile preload is higher than rivets—is more uniform than bolts and nuts. The lockbolt makes possible a more rigid joint because it fills the hole better than other fasteners.

Townsend lockbolts are available in steel and aluminum alloy, in 3/16", 1/4", 5/16", 3/8" and 1/2" diameters, in grip lengths ranging up to 2" in various head styles. Other material and lengths available upon request. They are described in Sweet's design file and in Townsend bulletin TL-101.

For a demonstration at your desk of how to get better, economical fastening with Townsend lockbolts, write on your company letterhead to Townsend Company, P. O. Box 237-E, New Brighton, Pa.

Licensed under Huck patent nos. RE 22,792, 2,114,493; 2,527,307, 2,531,048; 2,531,049.

Townsend

COMPANY • ESTABLISHED 1816

Sales Offices in Principal Cities

Men of Machines

the company in 1940. Mr. Smith, who has been manager of the Aviation Gas Turbine Div. since 1954, was previously associated with the Studebaker Corp. as chief administrative engineer for both gas turbine contracts and the Automotive Div.

Leonard C. Barr has been named vice president and director of operations, and **Robert C. Singleton** has been appointed vice president in charge of engineering by Gregory Industries Inc., Toledo, O.

Marchant Research Inc., Oakland, Calif., a subsidiary of Marchant Calculators Inc., has announced the appointment of **William L. Martin** as vice president.

William L. Martin

He will direct and supervise all research and engineering development work. Mr. Martin has been director of engineering for almost a year.

Paul Pick has been appointed chief engineer of the Allen Mfg. Co., Hartford, Conn.

Robert E. Corby has joined the engineering staff of Trio Laboratories Inc., Seaford, L. I., N. Y. Dr. Corby will supervise new product development.

Ozalid Div. of General Aniline & Film Corp., Johnson City, N. Y., has promoted **Frederick H. Frantz**

to the newly created position of director of engineering machine research and development; **Robert C. Goodman** to chief production engineer; and **Sheffield S. Campbell** to manager of quality control.

Albert Raitzer has joined the staff of the Products Engineering Dept. of the Trane Co., La Crosse, Wis. He is a project engineer assigned to work on high-temperature brazing and welding techniques.

Malcolm P. Herrick has been appointed staff assistant to the vice president in charge of the Telephone Div. of Stromberg-Carlson, a division of General Dynamics Corp., Rochester, N. Y. Mr. Herrick was chief engineer of the Radio-Television Div. He has been with the company since 1944.

Wayne C. Tustin has been promoted to supervisor of air-break switch engineering at the Santa Clara, Calif. plant of the Pacific Switchgear Div. of Federal Pacific Electric Co. He was formerly chief draftsman.

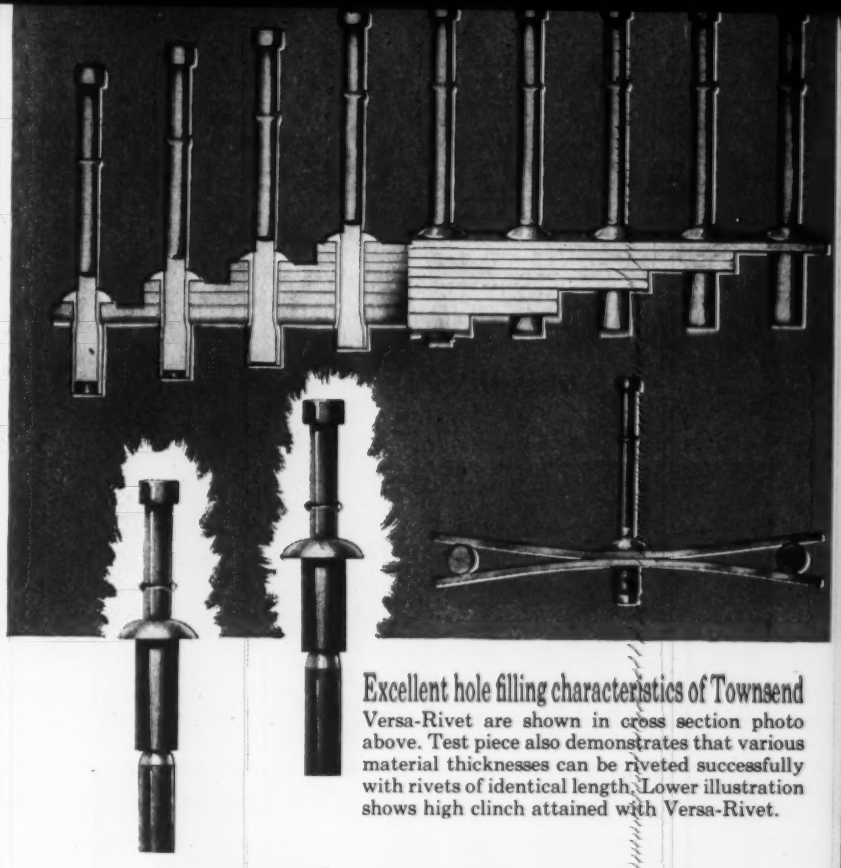
Century Electronics and Instruments Inc., Tulsa, Okla., has named **Richard Gode** chief design and development engineer for its switch division.

Thomas E. Spence has been named chief engineer of Nice Ball Bearing Co., Philadelphia. He will assume his new duties July 1.

Actuation Research Corp., Glendale, Calif., has announced the appointment of Siegfried Kaswan as staff engineer for mechanisms.

Murray Simpson has been elected an assistant vice president of the W. L. Maxson Corp., New York. He will head electronic research and development activities for the company. Before joining Maxson, Mr. Simpson directed development of a missile guidance system at Fairchild Guided Missiles Div.

Al Gross has been appointed chief engineer of Cleveland Metal Specialties Co., Cleveland. Mr. Gross, designer of the walkie-talkie, will



Excellent hole filling characteristics of Townsend Versa-Rivet are shown in cross section photo above. Test piece also demonstrates that various material thicknesses can be riveted successfully with rivets of identical length. Lower illustration shows high clinch attained with Versa-Rivet.

New Townsend Versa-Rivet Provides Versatile, Uniform Fastening Method

The hole filling qualities, wide grip range, high clinch, and positive stem retention now possible with the new Townsend Versa-Rivet give industry a uniformity of fastening never before available.

In the past, variations in hole diameter made it virtually impossible to completely fill the hole in every instance. This difficulty is eliminated with the Versa-Rivet which always adjusts to fill the hole and provides high stem retention.

The method of setting the Versa-Rivet also provides high clinch and makes it possible to use one length to fasten a wider range of material thicknesses. Positive inspection is easy since a properly set rivet is indicated by the amount of stem shoulder protruding above the rivet head.

The Versa-Rivet is available in the universal head with one length for each diameter. It is installed with standard Townsend rivet guns with controlled-stroke pulling heads and accessories.

A product of Townsend Research and Development Department, the Versa-Rivet has back of it over 100 years experience in the fastening industry. This organization has developed the widest range of types and sizes available in the industry. Townsend engineers have designed and built special purpose machines and developed techniques that make possible such innovations as the Versa-Rivet.

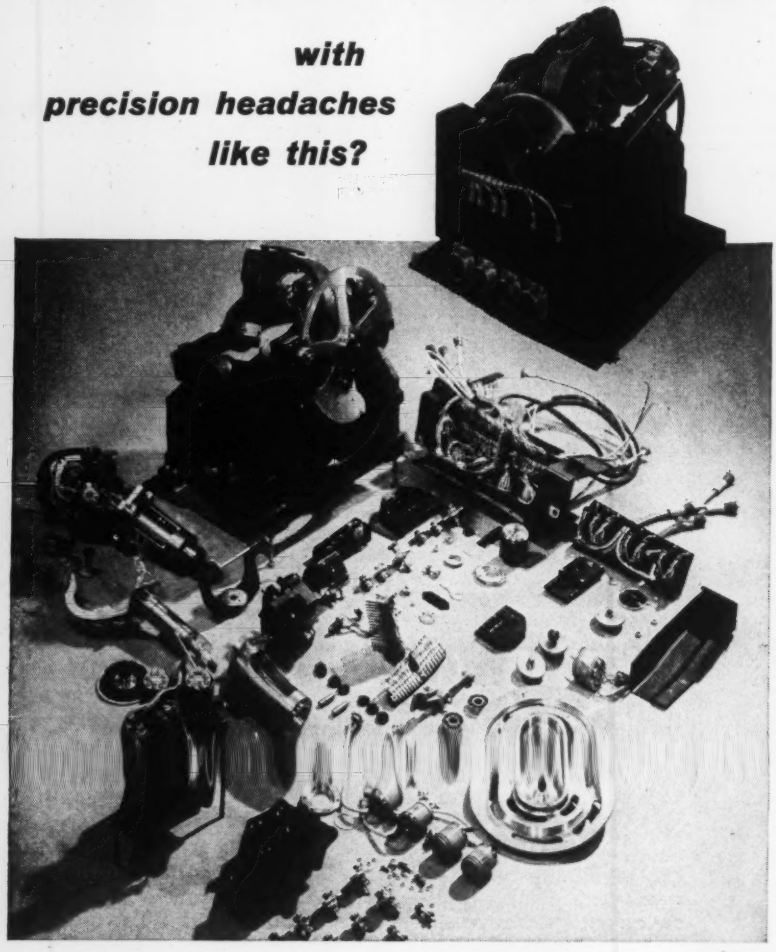
For technical data on how the Townsend Versa-Rivet will give you a more uniform method of fastening, write to Townsend Company, P.O. Box 237-E, New Brighton, Pennsylvania.

Townsend
COMPANY • ESTABLISHED 1816
Sales Offices in Principal Cities

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

Can you use help

with precision headaches like this?



Let General Mills work them out for you

Right now our systems engineering people and our factory can be at your service if you need volume piece parts or assemblies such as

- electro-mechanical systems or components
- fine-pitch, instrument-type gears
- precision parts, cutting, grinding, finishing
- industrial or military optical assemblies

Right now you can utilize the experience of our creative engineers and precision production plant—the same men and machines that have handled prime and sub-contract work like the bombing system computer above, the B-47's Y-4 bombsight, and similar complex systems. And of course we offer full laboratory and environmental testing facilities.

LET US BID on your specific requirements today. Save time, cut costs and eliminate the worrisome problems you face in recruiting competent engineers and skilled production hands. We have them now . . . and can rush delivery of parts or whole packages *in quantity, on time, to meet strict military specs.*

ASK FOR FREE NEW BOOKLET *covering complete manufacturing capacities and capabilities. Write, wire, or phone Dept. MD6, 1620 Central Ave., Minneapolis 13, Minn., STerling 9-8811.*

MECHANICAL DIVISION

OF General Mills, Inc.

—ITEM 527—

For More Information Circle Item Number on Yellow Card—page 19

Men of Machines

be in charge of the design and development of new products.

John E. Eckert recently was appointed vice president and chief engineer by Armzen Co., Waterbury, Conn.

F. R. Householder has joined the Plymouth division of Chrysler Corp. as a staff engineer. Mr. Householder has been associated with racing of automobiles for many years.

Severin Raynor has been appointed director of American Machine & Foundry Company's Mechanics Research Dept. in Chicago. Since August, 1954, Dr. Raynor has been chief of the Engineering Division, Chicago Midway Laboratories, of the University of Chicago. Previously he was senior scientist then chairman of the Structural and Propulsion Research Department of Armour Research Foundation; before that he was an associate physicist with the Manhattan Project at the University of Chicago.

Hays Corp., Michigan City, Ind., has announced the appointment of **Frederick M. Rutledge** as chief control engineer and **Crayton H. Schwestka** as chief design engineer.

Appointment of **James E. Trask** as head of the central machine design department of the engineering division has been announced by Minnesota Mining & Mfg. Co., St. Paul.

Rudy Schroeder has been named supervisor of product design by Clarostat Mfg. Co. Inc., Dover, N. H.

Gremco Inc., Fort Worth, Tex., has named **Fritz Bingaman** president. He has been chief engineer of the company's Fort Worth plant, and previously was associated with the American Car & Foundry Co., the Hamilton Standard Propeller Div. of United Aircraft Corp., the Beryllium Corp. of America, and the Murray Corp.

John H. Howard has been named director of research and engineering for Underwood Corp., New York. His headquarters will be in the company's General Research

John H. Howard

Laboratory in Hartford, Conn. Mr. Howard was formerly manager of engineering services for the Burroughs Corp. Previously he had been director of development for Engineering Research Associates Inc., project engineer for the Sperry Gyroscope Co., and a consultant.

Charles W. Burkland has been promoted to the newly created position of associate research engineer in the research and development division of Maytag Co., Newton, Iowa. A member of the advanced design project group, he was formerly a senior design engineer.

The Benjamin G. Lamme Medal will be awarded to **Robert M. Critchfield,** a General Motors Corp. vice president and general manager of the Pontiac Motor Div. The medal is awarded annually to an Ohio State University graduate in recognition of "meritorious achievement in engineering or the technical arts." Mr. Critchfield received his bachelor's degree in electrical engineering in 1916. He has been associated with General Motors since 1921.

Air Line Filters Reduce Wear, Cut Operating and Maintenance Costs

Norgren Filters Prevent Abrasive and Corrosive Materials from Damaging Air Activated Equipment

An air filter is vitally important to the design, installation and operation of any system powered by or using compressed air. Two types of contaminants must be removed from the air — solids, including pipe scale and rust; and liquids such as water and oil-water emulsions.

These contaminants, if allowed to reach air-powered tools or machine components such as bearings, gears, valves, cylinders, or other operating mechanisms, would cause excessive wear, corrosion, malfunctioning of the equipment and increased costs for maintenance, repairs and replacement.

HOW CONTAMINANTS ARE REMOVED

Figure 1 shows how one efficient type of filter, designed by the C. A. Norgren Co., removes solid and liquid contaminants from compressed air lines. The solids are extracted by

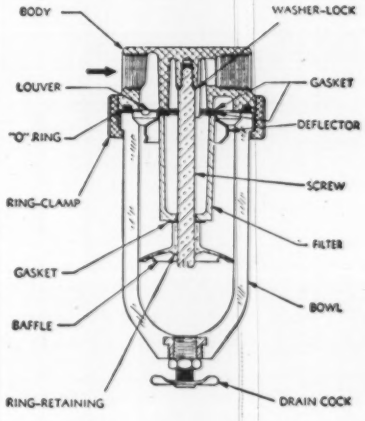


Figure 1

passing the air through a filter element. Interchangeable elements of three degrees of fineness are available —a 200 mesh (74 micron) Monel wire screen and sintered bronze with ratings of 64 microns and 25 microns.

To remove the liquids, air entering the filter is directed into the bowl through louver plates so that it enters tangential to the inner wall. This sets up a centrifugal flow pattern that forces the liquid particles to the inside walls of the filter. From here, the liquid runs down into a quiet zone in the lower portion of the bowl where a baffle plate prevents air turbulence from picking up the collected liquid and carrying it on through the filter. Accumulated liquids are removed by simply opening the drain cock. This type of filter is available with a transparent bowl that shows when draining is necessary, or a metal bowl for use at higher temperatures and pressures.

LATEST DEVELOPMENT— AUTOMATIC-DRAIN FILTER

The latest design of Norgren Filter, widely used by industry, is one that drains itself automatically. The Norgren Automatic-Drain Filter, Figure 2, removes solids and liquids in a way similar to that previously described. In addition, it automatically

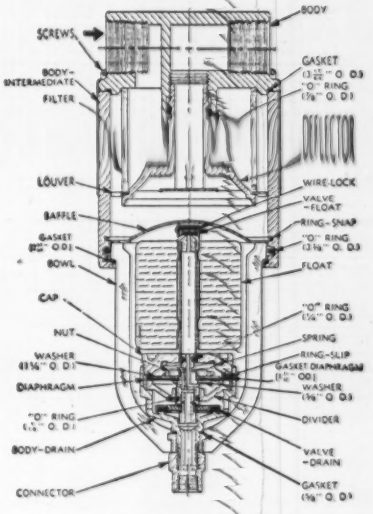


Figure 2

drains the collected liquids through a float-controlled, pilot-operated mechanism that discharges only when the liquid reaches a designated level. As long as there is pressure on the system, the drain operates around the clock, with or without air flow. Solids are prevented from entering the drain mechanism, preventing clogging and assuring trouble-free operation. A transparent bowl provides a clear view of the liquid accumulation and the drain action.

Norgren manufactures the most complete line of air line filters in pipe sizes and types to answer all the varying needs of industry. For complete information about Norgren Filters, phone your nearby Norgren Representative listed in your telephone directory — or write the factory for new catalog.

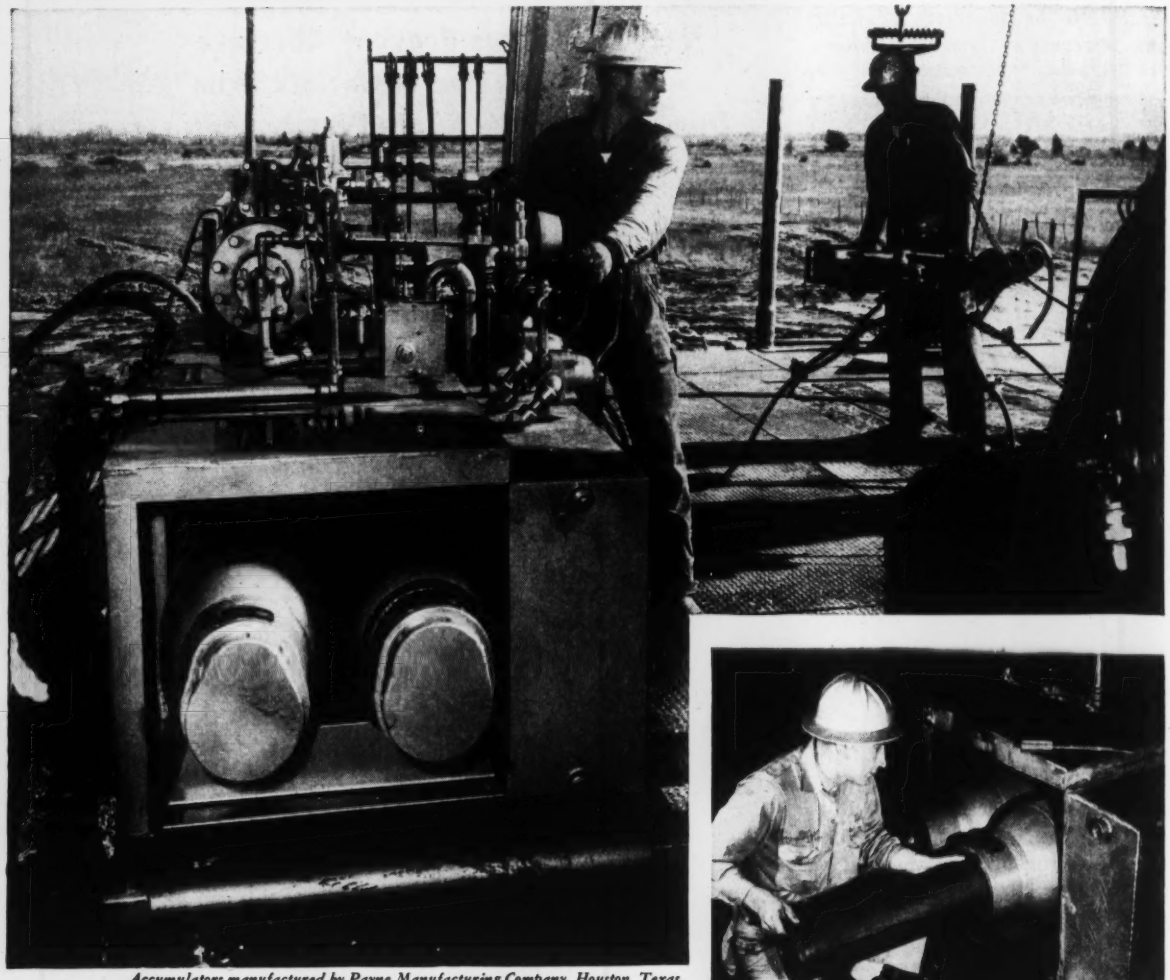
C. A. Norgren Co.

3442 So. Elati St., Englewood, Colorado

—ITEM 528—

Another new development using

B. F. Goodrich Chemical *raw materials*



Accumulators manufactured by Payne Manufacturing Company, Houston, Texas.
Hycar bladders by F. H. Maloney Company, Houston, Texas.

HYCAR STANDS BY TO STAND OFF BLOWOUTS

CYLINDERS made from Hycar nitrile rubber act as pistons inside the pressure accumulator of this blowout preventer. Hycar has to take unusual punishment to keep the blowout preventer on the job—ready, in case of rig power failure, to deliver a 2,000 psi punch to close off high pressure gas blowouts.

First, the Hycar bladders are pumped full of nitrogen to 1,000 psi. Then hydraulic fluid is pumped into the steel cylinders around the Hycar bladders until the pressure is 2,000 psi. This pressure is then always ready to operate the blowout seal-off—fast!

This is one of the toughest tests of Hycar's performance. It must withstand very high pressures, yet have the elasticity to inflate like a balloon. It must have toughness and abrasion resistance to take the scraping it gets from metal parts when pressure is suddenly released. And it must resist the deteriorating effect of the hydraulic oil.

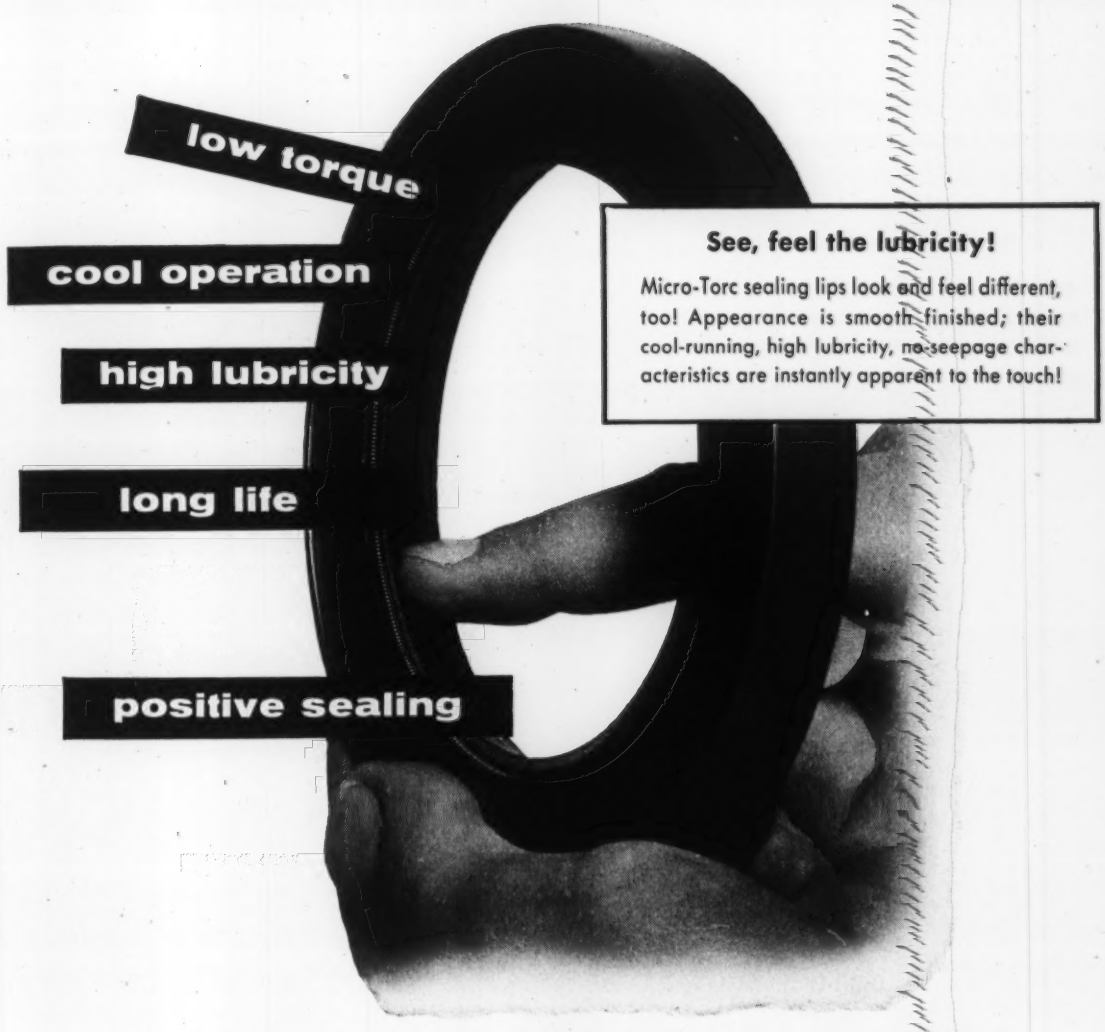
Many, many different characteristics can be built into products made from Hycar. The properties described here and many others often make Hycar the unique material that is the answer to design problems. For information on how Hycar can help with your particular requirement write Dept. EJ-3 B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B. F. Goodrich Chemical Company
A Division of The B. F. Goodrich Company

Hycar
Reg. U.S. Pat. Off.
American Rubber

GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors

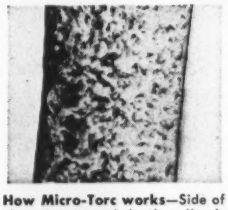
—ITEM 529—
For More Information Circle Item Number on Yellow Card—page 19



See, feel the lubricity!

Micro-Torc sealing lips look and feel different, too! Appearance is smooth-finished; their cool-running, high lubricity, no-seepage characteristics are instantly apparent to the touch!

NATIONAL MICRO-TORC* LEATHER OIL SEALS



How Micro-Torc works—Side of chrome retanned leather lip is coated with dry lubricant and elastomer. Elastomer binds lubricant to leather, prevents seepage through leather, enhances mechanical stability—yet permits leather's natural porosity to remain in body of sealing lip. Lip actually stores oil for dry or emergency running!

For applications where temperatures are within —50° to 200° F. and shaft speeds are not over 2000 rpm with runout .015 or better, new National Micro-Torc oil seals should definitely be investigated.

The Micro-Torc sealing member is perhaps the most interesting advance in leather oil seals in 15 years. In hundreds of thousands of hours of actual application, Micro-Torc seals have consistently shown up to 80% less torque and 10 times the life of other leather seals. Breakaway torque is normally only 20% of conventional leather seals, and Micro-Torc seals have operated up to 100 hours dry at 1,350 rpm without sloughing or squealing. Properly used, Micro-Torc seals provide positive sealing throughout service life.

Get complete details. Call nearest NMB Engineer, or write for Bulletin.

Engineering help in your plant and ours. NMB'S Application Engineering Service is fast, expert, convenient. Yours for the asking:

CHICAGO, ILL.	*Room 462 McCormick Building, HArrison 7-5163*
CLEVELAND, OHIO	*210 Heights Rockefeller Bldg., YEllowstone 2-2720*
DALLAS, TEXAS	*2520 West Mockingbird Lane, DIxon 7541*
DETROIT, MICH.	*13836 Puritan Avenue, VErmont 6-1909*
DOWNEY (Los Angeles Co.), CALIF.	*11634 Patton Rd., TOpaz 2-8163*
INDIANAPOLIS, INDIANA	*2802 North Delaware Street, WAlnut 3-1535*
KANSAS CITY, MO.	*4445 Terrace, LOgan 6622*
MILWAUKEE, WIS.	*647 West Virginia Street, BRoadway 1-3234*
NEWARK, N. J.	*1180 Raymond Blvd., Mitchell 2-7586*
REDWOOD CITY, CALIF.	*Broadway and National, EMerson 6-3861*
WICHITA, KANSAS	*519 South Broadway, AMherst 2-6971*

*T. M. REG.

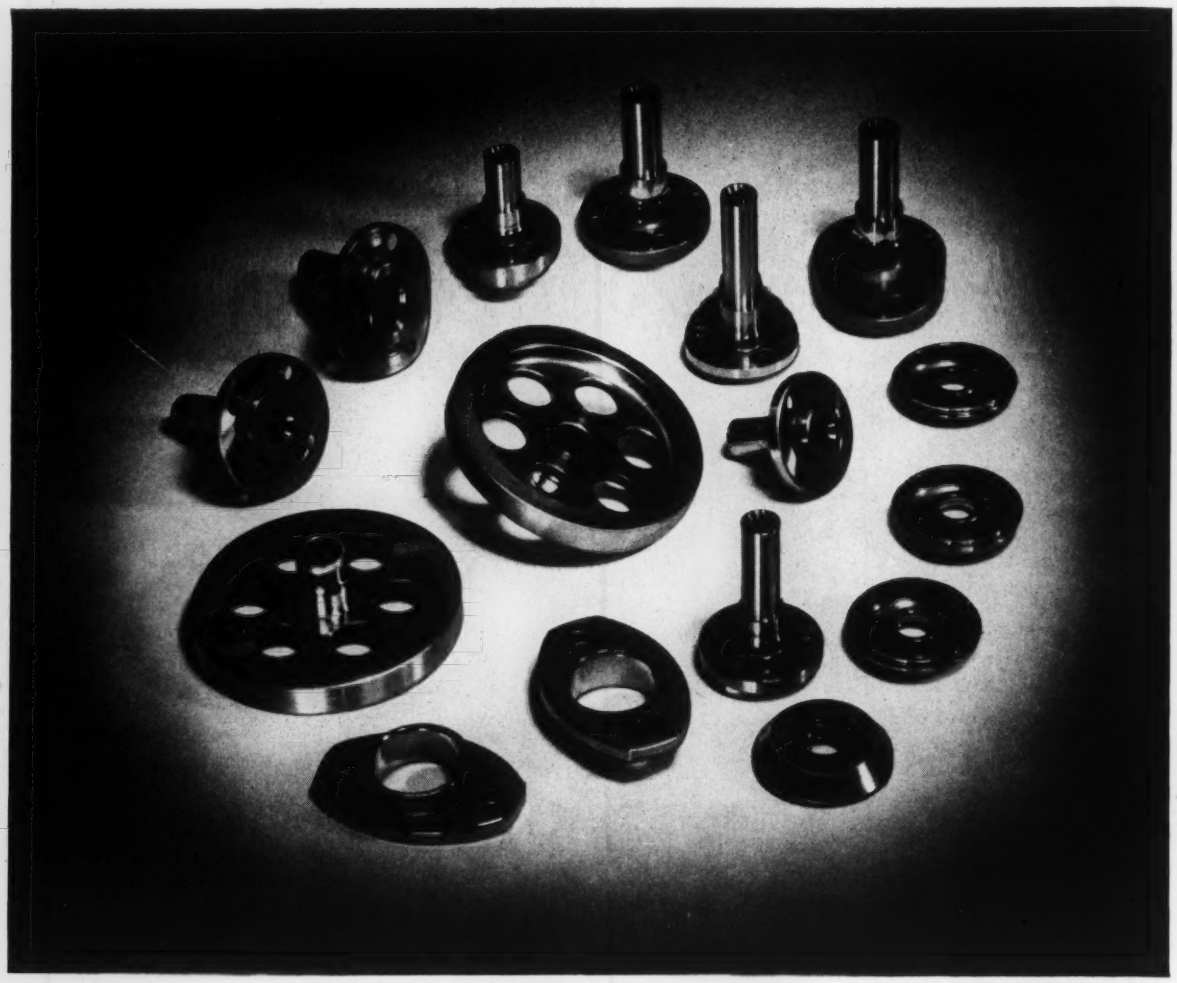
NATIONAL
OIL & GREASE SEALS
O-RINGS SHIMS
Product of the world's largest exclusive manufacturer of oil seals

3675

NATIONAL MOTOR BEARING CO., INC.

Plants at Van Wert, Ohio, Redwood City, Downey and Long Beach, Calif.
General Offices: Redwood City

—ITEM 530—



bearing manufacturer gains over 300% higher yield with Vacuum Metals FERROVAC

Because a leading manufacturer of precision instrument bearings worked to such exacting standards, he experienced an exceptionally high rate of rejection of finished parts. Then they tried Vacuum Metals FERROVAC®. . . of the same basic analysis as the air-melted grade used previously. The results were decisive. Rejections were reduced to less than 1% – a yield improvement of better than three times.

That's to be expected from vacuum-melted alloys, because of their remarkable uniformity. Gases that cause inclusions and that in turn lead to rejection – or early bearing failure – are literally sucked from vacuum-melted alloys during production . . . before the metal becomes solid.

The result is a *clean* alloy – with many of its properties improved. It is stronger, tougher, far more resistant to wear and fatigue. It works longer and harder than conventionally-melted alloy – even does the super-tough jobs where *nothing else* will work.

Only Vacuum Metals gives you one-source service – Vacuum Metals' own large organization, and its affiliation with National Research Corporation and Crucible Steel Company of America, brings you a fully integrated service. It includes everything from melting and casting, through mill rolling and nation-wide distribution of finished products. If you have an application where you can use vacuum-melted metals – in experimental lots or production quantities – Vacuum Metals can serve you. Write us now, outlining your requirements. *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, New York.*

VMC

VACUUM METALS CORPORATION

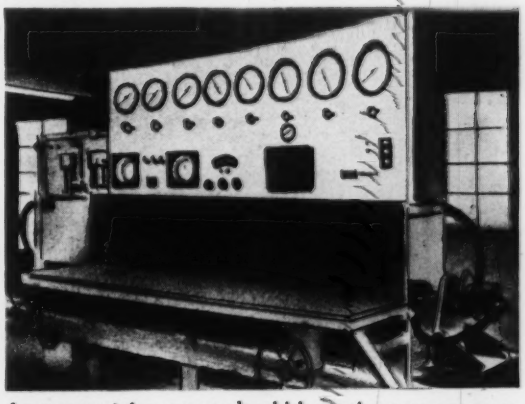
Jointly owned by Crucible Steel Company of America and National Research Corporation

—ITEM 531—

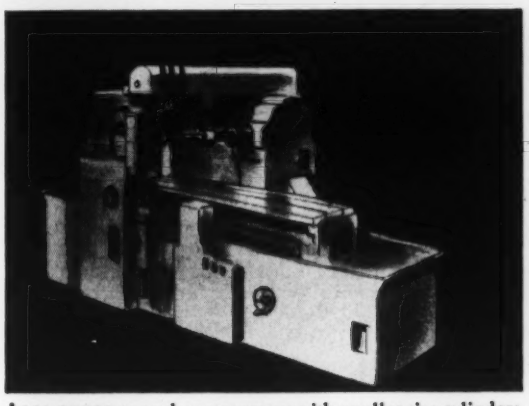
For More Information Circle Item Number on Yellow Card—page 19

How hydraulic systems are simplified with 2000 psi vane pumps

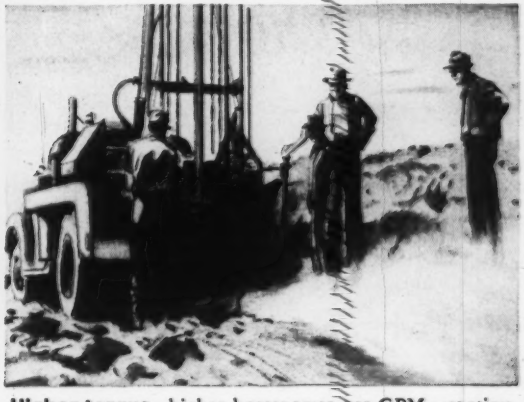
Lower weight on mobile equipment with smaller size lines, smaller controls.



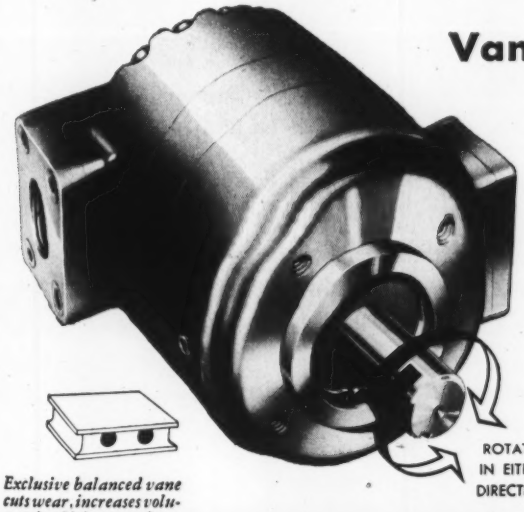
Lower cost for test stands which require pressures up to 2000 psi.



Less space to pack more power with smaller size cylinders and valves on hydraulic machines.



Higher torque, higher horsepower per GPM – continuously on drilling equipment.



Exclusive balanced vane cuts wear, increases volumetric efficiency, reduces pulsations.

Vane-Type DENISON hydraulic, single stage pump/motor

INDUSTRY'S STANDARD FOR CONTINUOUS 2000 PSI SERVICE

Many types of hydraulic circuits are made simpler with the 2000 psi system using the Denison vane pump. Less space is needed, weight of pumps and controls is lower. Line loss inefficiency is greatly reduced because of the lower volumes required with a 2000 psi circuit.

As a pump, this Denison unit has high volume output at 2000 psi continuous delivery. As a motor, it delivers a high stalled torque . . . up to 257 inch-pounds per 1000 psi.

Write for Bulletin P-5-A for complete specifications on 4 sizes available for delivery up to 77 gpm as a pump and 1 to 103 hp as a motor.

DENISON Hydr OIL ics

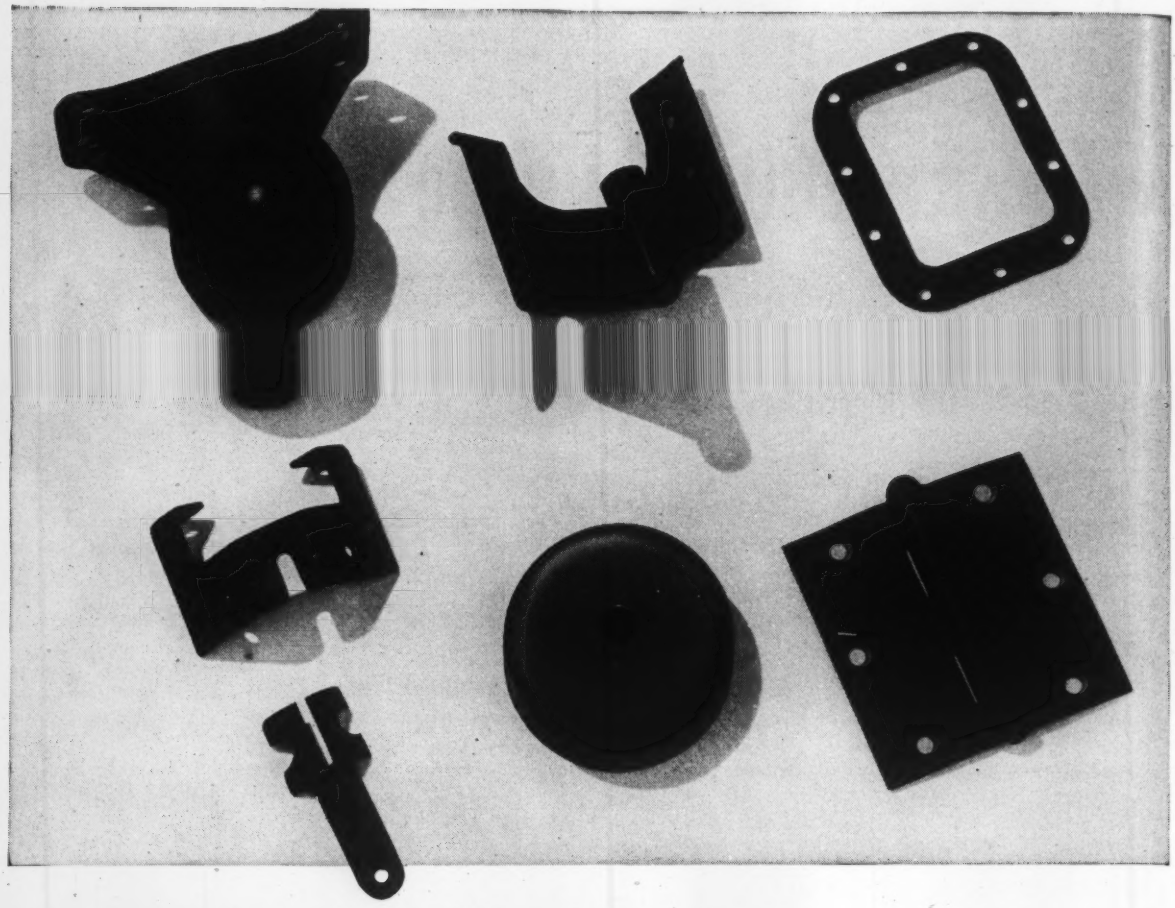
HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

THE DENISON ENGINEERING COMPANY

1240 Dublin Road • Columbus 16, Ohio

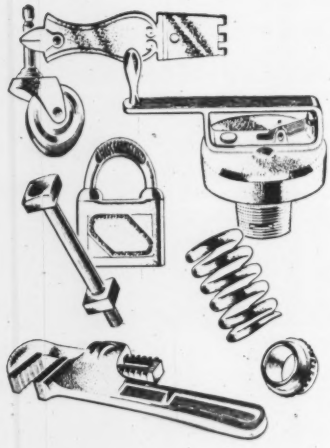
A Subsidiary of American Brake Shoe Co.

—ITEM 532—



A manufacturer of metal stampings writes:*

"There are many outfits offering something like Parkerizing, but we want the real thing."



Some typical parts which are protected from rust by treatment with Parco Compound

Parco Compound† (Parkerizing†) is the original rust-resistant phosphate coating for iron and steel. For forty-two years it has protected hundreds of different types of products—from bolts to boats.

There are other products "like" Parkerizing, but none quite so effective, so dependable, so thoroughly tested and proven.

Parkerizing is simple, fast, and costs very little. It can be used on any iron or steel article which can be immersed in the tanks. Since it does not change the dimensions of the treated parts, it is excellent for threaded or close-fitting components. Parts treated with Parco Compound may be finished with stains, waxes, oils or paint.

You, too, should demand "the real thing." Use Parkerizing for rust resistance.

**Name on request.*

†Parkerizing, Parco—Reg. U.S. Pat. Off.

PARKER RUST PROOF COMPANY

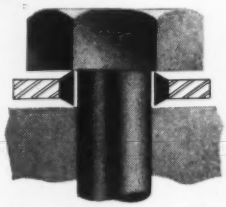
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

Since 1914—leader in the field

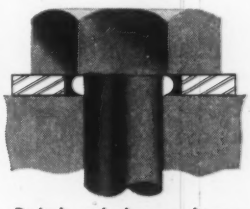
BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

—ITEM 533—

Leak-proof Precision Dyna-seals
solve countless sealing problems



Dyna-seal before bolt head is drawn down



Bolt head drawn down —with pressure applied

How pressure forces sealing lips against surfaces

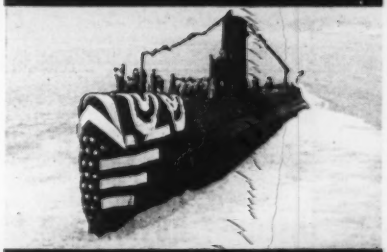
Vibration Proof, Lock Washer Action

Dyna-seals bring to an end an age-old leakage problem on face-to-face connections. They provide a positive and economical liquid or vapor seal against a steady or pulsating pressure of up to 10,000 P.S.I.

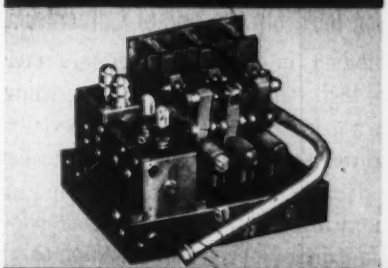
The practical Precision Dyna-seal is an easy-to-handle one piece unit, consisting of a flared rubber sealing ring, heat and pressure bonded to a steel washer. No grooves or special machining required. Permanent, leak-proof sealing without excess stress. (Bolting torque is reduced.) Simplicity of the Precision Dyna-seal greatly reduces tooling and assembly costs.

Dyna-seals give exacting performance under bolt and rivet heads, cap nuts, flanges or special fittings. Let a Precision engineer demonstrate the Dyna-seal cost and labor saving advantages to you. Write today!

Typical Dyna-seal Applications

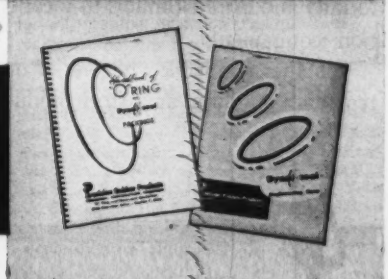


Dyna-seals provide uncompromising sealing performance under bolt heads of the nuclear submarine Seawolf periscope mounting.



30 Dyna-seals solve plug-leakage problem on The NATCO Hydraulic Control Unit manifold.

Write for your free copy of the Precision catalog on Dyna-seals



Precision Rubber Products
Corporation • "O" Ring and Dyna-seal Specialists

Dept. 9, Oakridge Drive, Dayton 7, Ohio

Canadian Plant at:
Ste. Thérèse de Blainville, Québec

—ITEM 534—

Discover how these ELEVATED TEMPERATURE ALLOYS can give you

√ Improved Forgeability √ Greater Uniformity √ Cleaner Steels

Exciting possibilities for improvement are ahead when you look into the line of Carpenter alloys for parts or products in elevated temperature service. Here is a line of high temperature and heat-resisting alloys produced in a *specialty* mill. Only a true specialty mill can produce so well these very difficult-to-make alloys.

Here, too, is a combination of unusual advantages not normally found in this type of alloys. For example, Carpenter pioneered the addition of rare earth elements to the analyses of certain grades to give you improved forgeability. And Carpenter's unsurpassed, meticulous quality controls, assure you steels with greater uniformity and extra cleanness to meet the strictest inspection requirements.

Whether you work with one of our present elevated temperature alloys, or a steel produced specifically for your own application, you'll find that Carpenter's wealth of fabricating and working information will help you substantially reduce production costs and get better parts.

Outline your plans or problems to your Carpenter Representative or write direct. You'll get the kind of help that pays off with definite improvements. *The Carpenter Steel Co., 120 W. Bern St., Reading, Pa.*

Specify Carpenter alloys for elevated temperature service and get these three big advantages . . .

Improved Forgeability
Greater Uniformity
Cleaner Steel

Carpenter STEEL

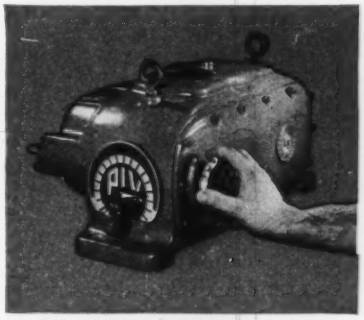
Improved Alloys for Elevated Temperature Service

—ITEM 535—
For More Information Circle Item Number on Yellow Card—page 19

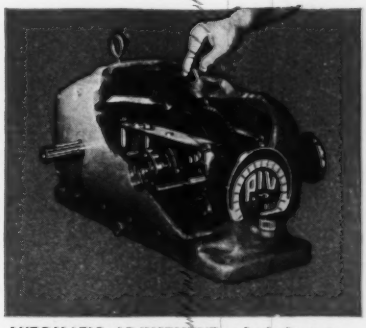
Because it uses a positive chain rather than frictional elements to transmit power...LINK-BELT P.I.V. delivers

variable speeds with unvarying accuracy

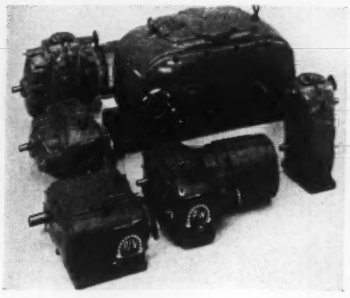
Throughout industry, chain drives have long been preferred as a simple, versatile method of transmitting power positively and accurately. But it was not until the conception of Link-Belt P.I.V. that this advantage was adapted to variable speed drives. With its self-tooth-forming chain principle, P.I.V. provides instant selection of any speed between its maximum and minimum settings without stopping the machine.



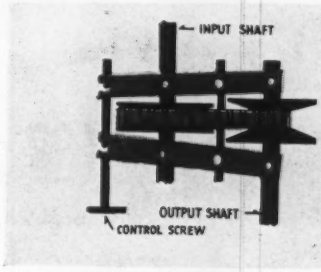
TO CHANGE OUTPUT RPM, operator merely turns convenient handwheel to selected speed, indicated by easy-to-read dial.



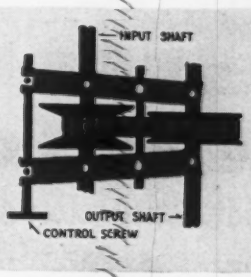
AUTOMATIC ADJUSTMENT of chain tension—by turning hand screw—assures accuracy during long life of drive.



P.I.V. drives are built in capacities from ½ to 25 hp, in 8 sizes and 16 types. Compactness permits installation as a separate unit or built-in part of driven machine.



AT MAXIMUM SPEED SETTING . . . chain grips wheel grooves near perimeter of input side and near center of output side.



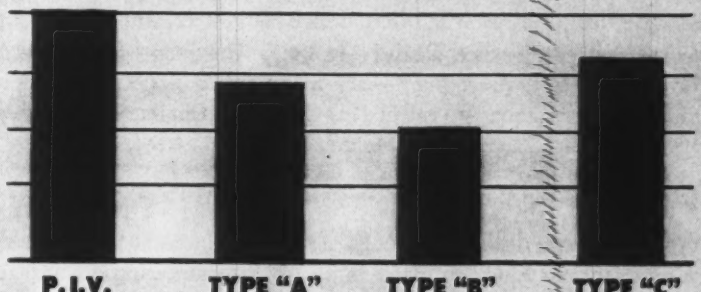
AT MINIMUM SPEED SETTING . . . relative position of chain to wheels is reversed, delivering low output shaft rpm.

THE exclusive P.I.V. chain consists of a series of overlapping steel slats. These are free to move transversely from side to side, singly or collectively, serving as teeth. The chain meshes with radially grooved wheels, which are cut at a constant depth toward the wheel periphery. Beveled sides of the grooves offer gripping areas . . . provide a positive, non-slip contact at any speed, under all loads.

All-metal construction of P.I.V. is unaffected by atmospheric conditions. Housings are of close-grained gray iron—internal moving parts are automatically splash-lubricated.

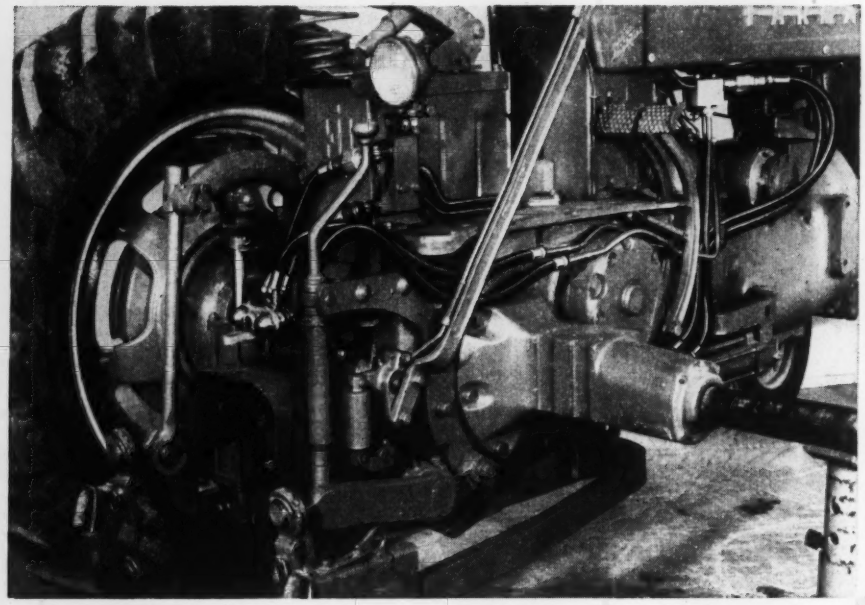
You'll find much interesting and valuable information concerning P.I.V. in Book 2274 Link-Belt also makes mechanical, hydraulic, electronic and pneumatic controls for regulating these drives automatically, and these are detailed in Book 2349. Ask your Link-Belt office.

COMPARISON OF ACCURACY WITH P.I.V. AND 3 OTHER VARIABLE SPEED DRIVES



Using P.I.V. as a standard, bars indicate comparative ability to maintain desired rpm from no-load to full-load relative to three conventional variable speed drives. Chain principle of P.I.V. minimizes speed drop—loss of accuracy which may affect product quality and uniformity. Operating independent of friction, P.I.V. provides instant, positive selection regardless of load or atmospheric conditions.

LINK-BELT COMPANY: Executive offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,104



INTERNATIONAL HARVESTER'S

McCORMICK FARMALL 400 Tractor controls every implement action hydraulically through its famous Hydra-Touch hydraulic system. Individual, closely grouped levers permit independent or unison control of cylinders.

HYDRAULIC POWER controls plow penetration and depth automatically, lifting and locking in traveling position.

HYDRAULIC POWER controls angle and depth of disc penetration on International Fast-Hitch Buck and Bog Harrow.

HYDRAULIC POWER enables Farmall 200 Hydra-Creeper to travel 1/5 to 1 mile per hour for transplanting.

HYDRAULIC POWER permits raising right, left, or rear cultivator gangs separately, together, or any combination.

HYDRAULIC POWER . . . DELIVERED THROUGH

Eastman

HYDRAULIC HOSE ASSEMBLIES . . .

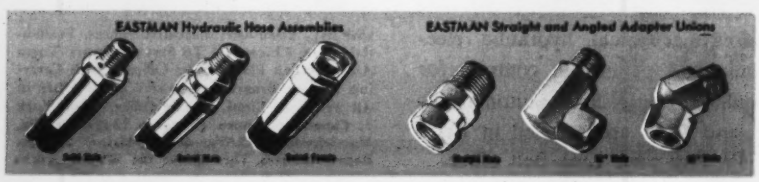
Most competitive Farm Implement Sales Feature

HYDRAULIC POWER probably contributed more to the usefulness, efficiency, and easy operation of farm tractors than any other modern engineering development. Farmers appreciate hydraulic advantages so much that they have become one of the *most competitive features in implement and tractor sales promotion.*

EASTMAN MANUFACTURING COMPANY is proud to have among its many agricultural users the International Harvester Company—dating back to the first McCormick Reaper—in 1831. Eastman—*first in the field* of Hydraulic Hose Assemblies—lists many other agricultural implement manufacturers among its users: J. I. Case, Allis-Chalmers, Massey-Harris-Ferguson, Inc., Minneapolis-Moline, Farmhand, Avco, and others.

IMPROVE THE COMPETITIVE POSITION OF YOUR PRODUCTS with Hydraulic Power—delivered through Eastman Hydraulic Hose Assemblies. Always specify Eastman: First in exclusive engineering advantages and design! First in materials and workmanship! *First in the field* of Hydraulic Hose Assemblies!

WRITE **Send your specifications and blueprints for our original equipment quotations.**



Eastman

first in-the-field

MANUFACTURING COMPANY

Dept. MD-6, Manitowoc, Wis.

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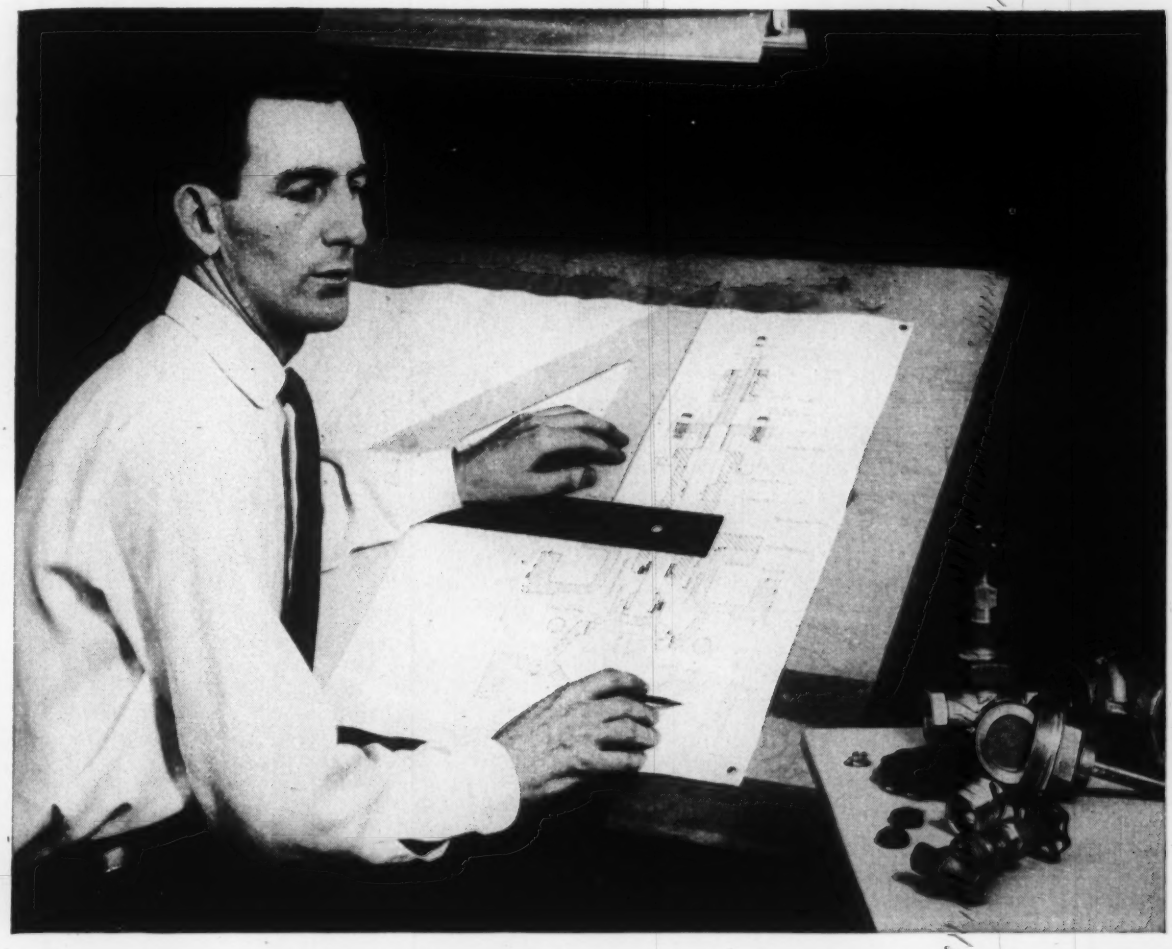


Valve designers and engineers . . . it will pay you to specify

R/M "CUSTOM-MADE" VALVE STEM PACKINGS

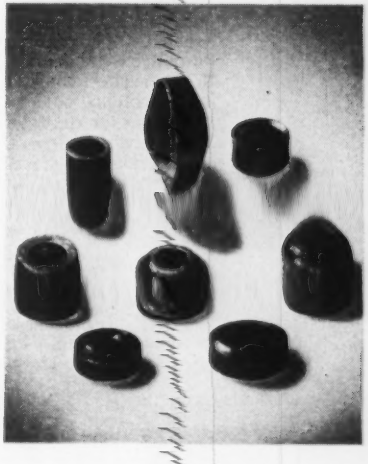
Regardless of the service requirements of that valve you're working on, there's an R/M Valve Stem Packing that will solve your sealing problem. Water, steam, gases, petroleum derivatives, and caustics all can be handled, even under the most adverse pressure and temperature conditions.

R/M die-formed Valve Stem Packings can be supplied in two general types: braided (asbestos yarns) and fibrous (plastic). The only limitation on shape is the type of construction desired. A wide variety of binders and lubricants can be furnished to meet individual requirements.

In addition to the die-formed types described, R/M can provide die-cut and lathe-cut rings from many types of rubber and synthetic rubber, with or without fabric reinforcement.

One of the pioneers in the packing industry, R/M offers complete cooperation in the development of a packing to fit your individual requirements.

For complete information, send for brochure on Custom-Made Valve Stem Packings



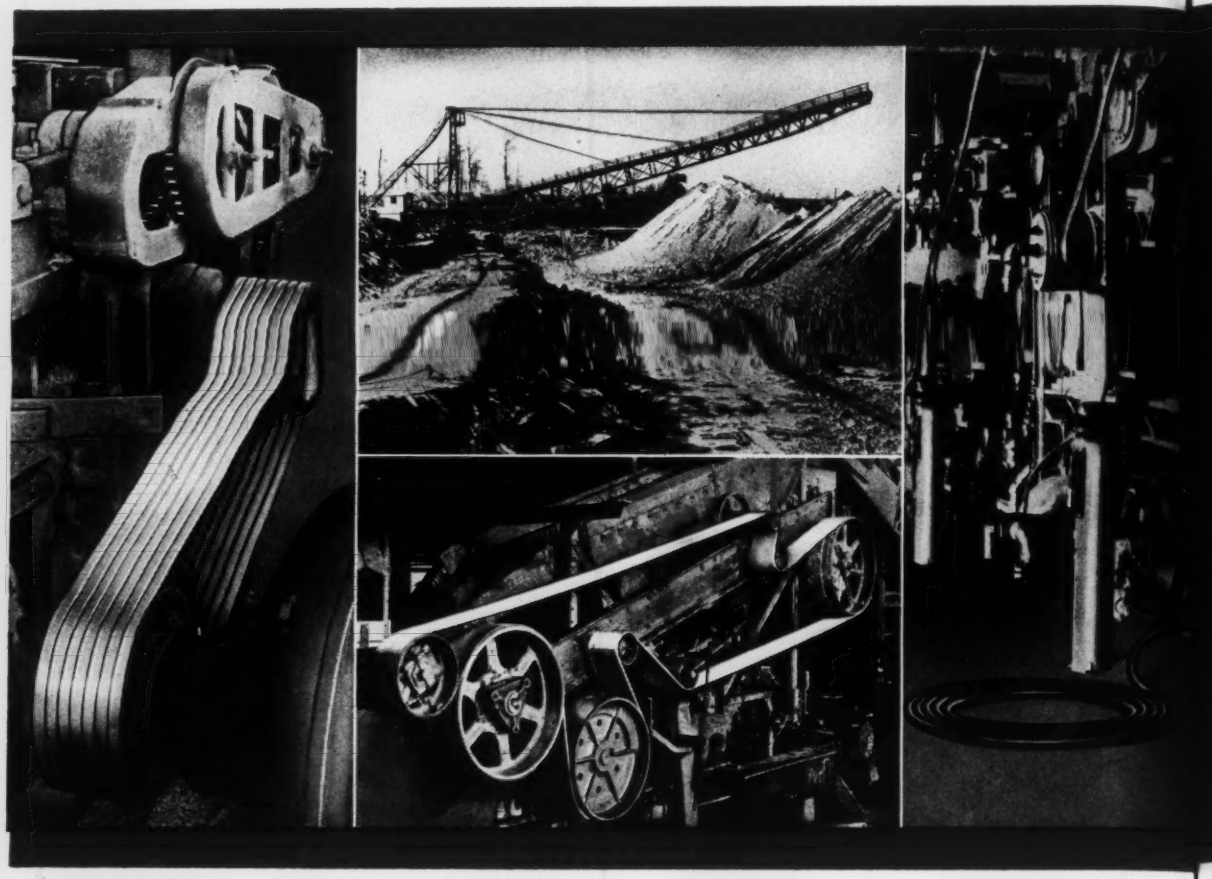
PACKINGS
RAYBESTOS-MANHATTAN, INC.
PACKING DIVISION, PASSAIC, N.J.
MECHANICAL PACKINGS AND GASKET MATERIALS

FACTORIES: Bridgeport, Conn.; Manheim, Pa.; Neenah, Wis.; No. Charleston, S. C.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC.: Packings • Asbestos Textiles • Industrial Rubber, Engineered Plastic, and Sintered Metal Products • Abrasive and Diamond Wheels • Rubber Covered Equipment • Brake Linings • Brake Blocks • Clutch Facings • Laundry Pads and Covers • Bowling Balls

—ITEM 538—

CALL ON R/M ENGINEERING SERVICE



R/M RUBBER PRODUCTS FOR BETTER PERFORMANCE, LOWER COST

Advanced engineering backed by over 60 years manufacturing experience serves the design engineer who depends on R/M mechanical rubber products. A complete line of R/M engineered conveyor belts, for example, includes Ray-Man Conveyor Belt with *extra* flexibility, *extra* tear resistance for heavy duty applications where thick, narrow belts and small pulleys are required. Other constructions are specially designed for portable and package conveyors. If you use hose, R/M has light Homoflex Hose with rope-like flexibility for air tools and water; all-purpose constructions like new Allflex for air, water, oil, gases and mild chemicals. Special burst-resisting types with wire insertion can be made for high pressure to handle steam and air safely. Whatever your requirements, let R/M work with you.

Condor and R/M Super-Power V-Belts are made with straight sidewalls to assure better tensioning and grip, less slip and longer life. Users call them "the smoothest running V-belts made." Where flat belt drives are used, R/M offers a complete selection of belts and driving surfaces from low tension to desired slip for every requirement. Most revolutionary is the new space-saving R/M Poly-V® Drive that combines the positive tracking and V grip of V-belts with the strength and simplicity of flat belts in a *single* endless belt drive. It delivers up to 50% more power in the same space as multiple-belt drives or equal power in ⅔ the space—with no multiple-belt matching problems!

R/M also designs and mass produces engineered molded parts of natural and synthetic rubber or silicone in any size or shape to meet your specifications.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METALS, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings

Fan Belts and Radiator Hose

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

—ITEM 539—
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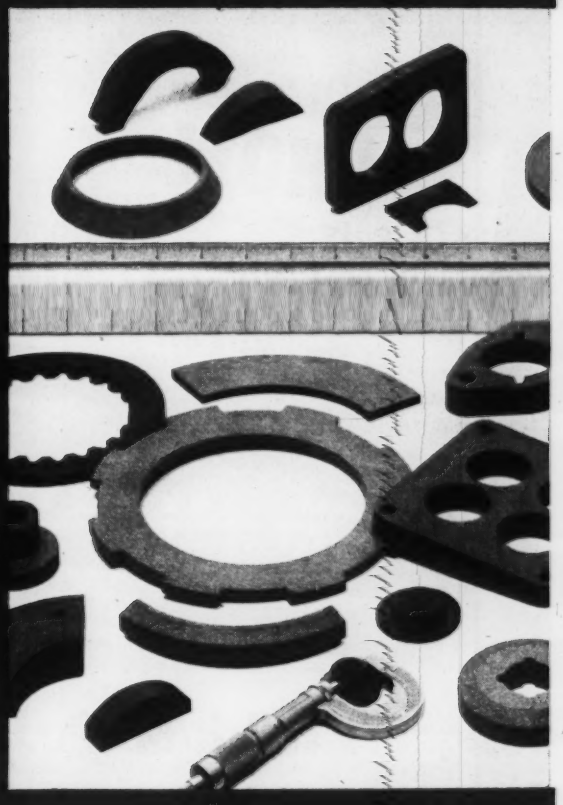
FOR HELP IN SOLVING YOUR PROBLEMS



PACKINGS, GASKETS ASBESTOS TEXTILES and "TEFLON"* PRODUCTS

If you are designing or making equipment that must operate under the most adverse conditions, R/M "Teflon" packings and gaskets may be the answer to your sealing problem. They have proved to be impervious to all known industrial acids, caustics and solvents; have zero water absorption; and show excellent resistance to weathering.

The complete R/M "Teflon" line includes mechanical packings and gaskets, sheets, rods and tubes, thin-wall tubing, tape, and special shapes made to order. "Teflon"-impregnated asbestos sheets and packings are also available. Don't hesitate to call on R/M for answers to your particular problems.

*Du Pont Trademark

For booklet shown, or other data, write, phone or wire.

PACKING DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J. • GRegory 3-2000

ASBESTOS TEXTILE DIVISION
Raybestos-Manhattan, Inc.
Manheim, Pa. • Manheim 5-2211

PRECISION MOLDED PRODUCTS

Precision molding is a mass-production method developed by R/M for economically manufacturing asbestos, with binders and fillers, into finished parts for structural and friction applications to accurate dimensions. Depending on quantity, size and shape, precision molded parts not only cost less, because machining is reduced or eliminated, but also frequently give better performance as well. Unlike other manufacturers, R/M works with all kinds of friction materials. So that whether you need precision molded products or some other type part, you can be sure of unbiased advice when you bring your problem to R/M.

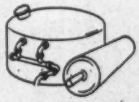
New R/M Bulletin No. 550 contains complete design and engineering data on precision molded products. Write for your copy. For technical information on all other R/M friction materials, ask for Bulletin No. 500.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
6010 Northwest Highway
Chicago 31, Ill.
ROdney 3-2400

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Conveyor Belts



Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

—ITEM 540—
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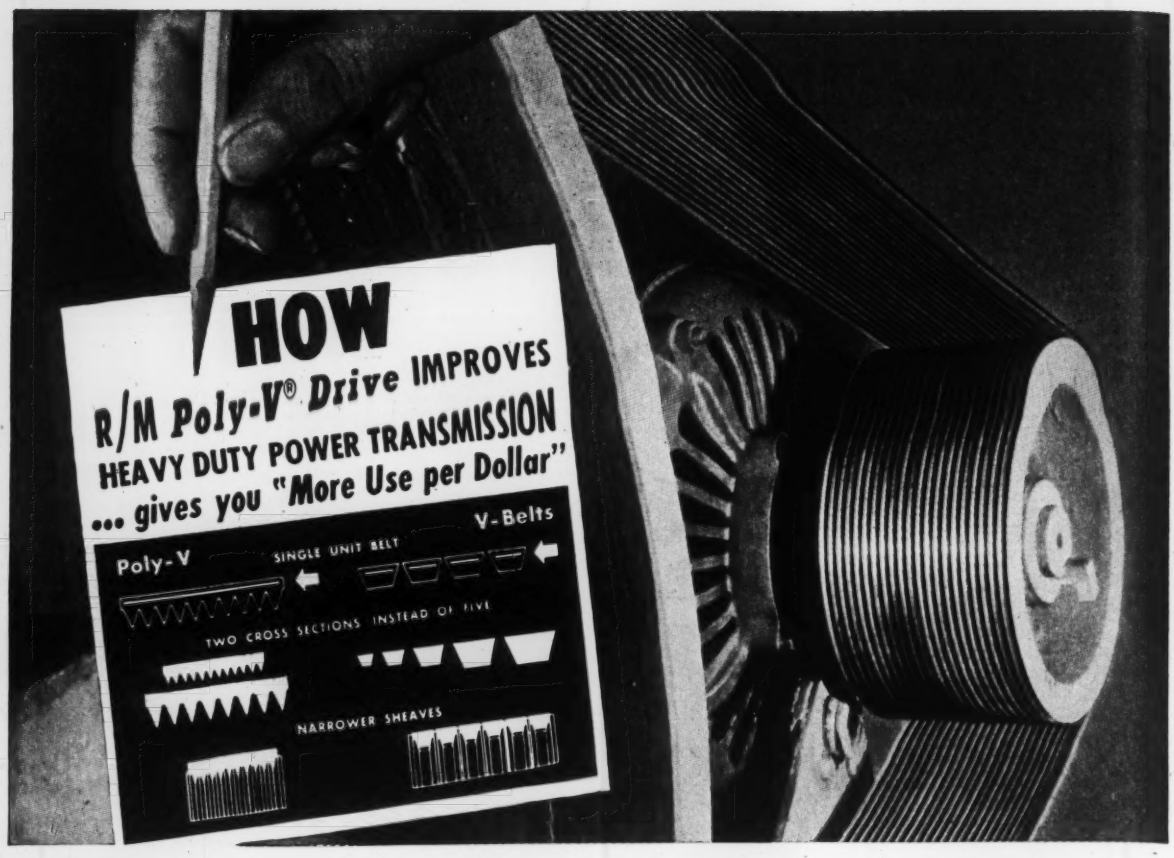

Designers call R/M *Poly-V*® the "ideal" belt drive

Here it is . . . Raybestos-Manhattan's answer to design engineers' demand for a superior belt drive to simplify heavy duty power transmission. It's the patented R/M Poly-V Drive . . . the only completely new concept in power transmission which combines the strength and simplicity of flat belts and the high V grip and positive groove tracking of V-belts!

Why has it proved the "ideal" drive for a great variety of applications?

It saves space. R/M Poly-V Drive employs a single, endless, parallel V-ribbed belt running on sheaves designed to mate precisely with the belt ribs. Because this single unit belt has a much higher horsepower capacity per square inch than ordinary V-belts, drive sheaves are narrower. You get up to 50% *more* power delivery in the same space as a standard multiple V-belt drive, or *equal* power in as little as 2/3 the space . . . with *less* shaft overhang and *less* drive weight.

Poly-V Drive maintains constant pitch diameter at all loads. No more sinking of belts in the sheave grooves: Poly-V belt speed ratio and belt position remain more constant from no load to full load to run smoother, cooler, with less wear on belt and sheaves. Just two cross sections of Poly-V Belt meet every heavy-duty power transmission requirement, as compared to five with V-belts. R/M Poly-V Drive cuts costly belt and sheave inventories to a new low!

R/M engineers who developed Poly-V Drive will be glad to give you further data on these and other advantages of this amazing new drive . . . and to work with you to determine the installation that will mean "More Use per Dollar" for your application. Contact an R/M representative . . . or write for a copy of Poly-V Drive Bulletin #6638.

CONDOR V-BELTS • R/M SUPER-POWER V-BELTS

Write for Bulletin #6868 on the complete line of Condor V-Belts for regular service on conventional V-belt drives. Also write for Bulletin #6628 on R/M Super-Power V-Belts with 40% more Horsepower capacity where needed.

*Poly-V is a registered Raybestos-Manhattan Trademark RM-628

MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.

Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings Asbestos Textiles • Packings • Engineered Plastic, and Sintered Metal Products • Laundry Pads and Covers • Bowling Balls

—ITEM 541—
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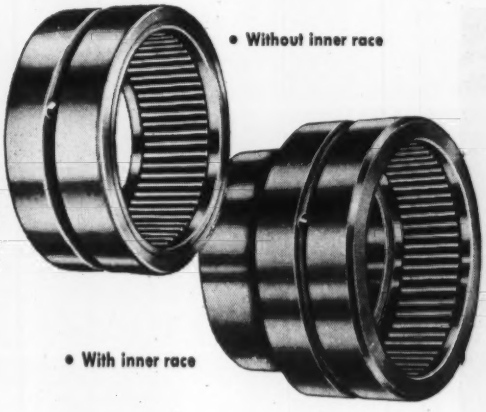
ORANGE NEEDLE BEARINGS

—offer widest choice of types and sizes to match your design needs

—greater opportunity to simplify design—fight friction—meet load requirements—save space and cost.



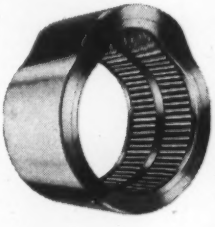
• Without inner race

• With inner race

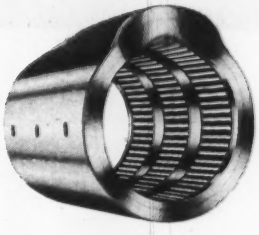
ORANGE *Full Type* ROLLER BUSHINGS

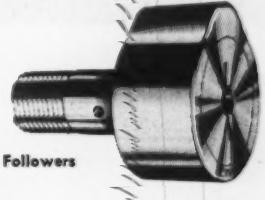
Maximum load capacity in small space

Orange Roller Bushings are full-type needle bearings for heavy-duty service. Rollers and races made of finest bearing steel—hardened, ground and finished to highest precision standards for durable, friction-free operation. Exacting control of roller uniformity by electronic gauging, permits closer internal running clearances, minimizing possibility of misaligned rollers. Complete range of stock sizes from ½" to 8" shaft diameters.



• Two and three row types for extra heavy duty





• Cam Followers

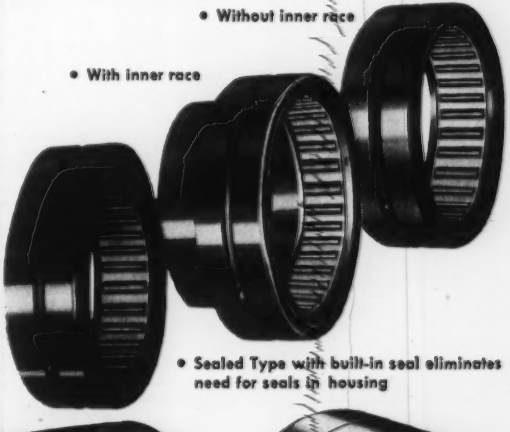
ORANGE *Cage Type* NEEDLE BEARINGS

Permanent alignment of rollers prevents skewing

Anti-friction cage keeps rollers permanently aligned and true-running in any position—vertical, tilted, horizontal. Successful on overhung mountings and relatively high-speed installations. Less affected by misaligned mountings or uneven loading. Extremely smooth, quiet running. The answer to many applications unsuited for conventional needle bearings. Wide choice of sizes from ½" to 8" diameter.

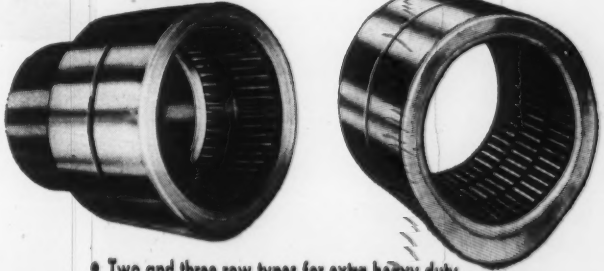
• Without inner race

• With inner race



• Sealed Type with built-in seal eliminates need for seals in housing

WRITE for new 40-page Engineering Reference Manual M-55 giving complete details of construction, dimensions, capacities, etc.



• Two and three row types for extra heavy duty

ORANGE ROLLER BEARING CO., INC., 556 Main Street, Orange, N. J.

—ITEM 542—

For More Information Circle Item Number on Yellow Card—page 19

Guarantee TOP Performance and Maximum Life!

Specify THESE TOP QUALITY FEATURES...

(Standard on Miller Cylinders at no extra cost)

Specify CASE HARDENED CHROME PLATED PISTON RODS

On all Air and Hydraulic Cylinders

Benefits To You

CASE-HARDENED Piston Rods (52-54 Rockwell "C") provide practically complete protection against damage from hammer blows, wrench-dropping, mishandling, and similar occurrences. ***Available from Miller at no extra cost.***

The HARD CHROME PLATING over the case-hardened rods protects against scratch-damage and rust. ***Available from Miller at no extra cost.***

Specify TEFLON WIPERS

On all Air and Hydraulic Cylinders

Benefits To You

"TEFLON" Rod Wipers and "TEFLON" Hydraulic Piston Rod Seals withstand temperatures from—100°F. to plus 500°F. They are impervious to practically all known chemicals, including the fire-resistant, special, and standard hydraulic fluids in current use. ***Available from Miller at no extra cost.***

Specify TEFLON HYDRAULIC ROD SEALS

On all Hydraulic Cylinders

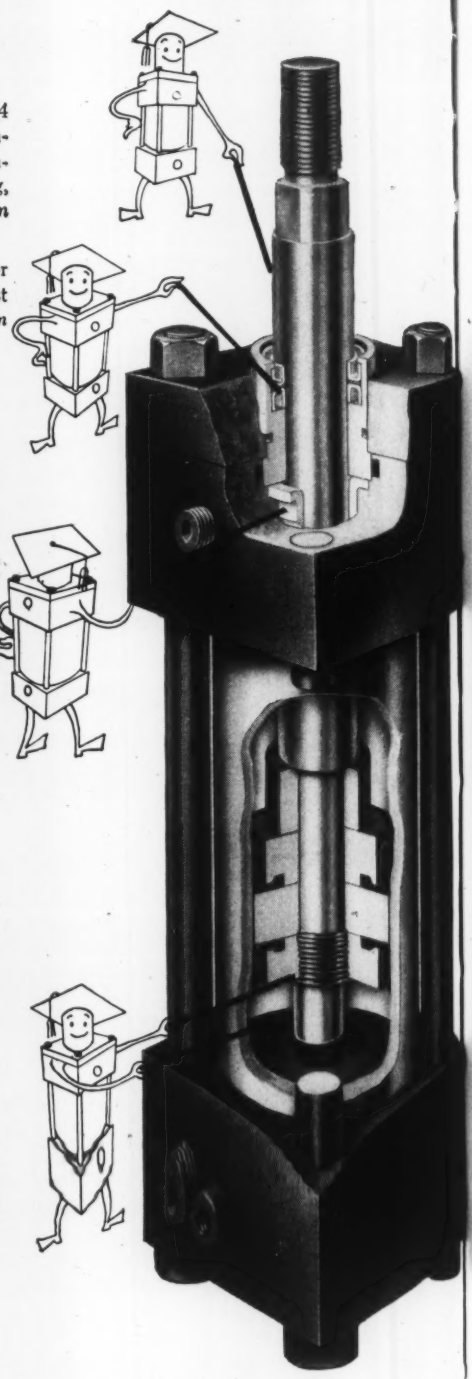
Benefits To You

Highest quality Black Ferric Oxide Finish provides rust protection in air cylinder operation and on all cylinders during shipping and installation.

Cylinder heads, caps, mountings, pistons, followers, tie rods, and the unplated portions of the piston rods have this finish *at no extra cost on all Miller cylinders.* (This finish not recommended for water service)

Specify RUST RESISTANT

On all Air and Hydraulic Cylinders



You may wish to route this entire page to the proper department in your company, by using this handy form. Additional copies on request. →

To (Dept.)_____

"On all our future cylinder requirements, please specify the above quality features."

Signed_____

Title_____

NOTE. On all Miller Hydraulic Piston Seals: Leather Cup Seals are *standard*, Piston Ring Seals are optional *at no extra cost*, and "Teflon" Cup Seals are available *at extra cost.*

Member of the National Fluid Power Association

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • TOLEDO • CINCINNATI • COLUMBUS PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY BUFFALO • ROCHESTER • MINNEAPOLIS • GRAND RAPIDS • DETROIT • FLINT FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE KANSAS CITY • SEATTLE • LOS ANGELES • SAN FRANCISCO • BALTIMORE DENVER • ST. LOUIS • MOLINE • CHICAGO • HOUSTON • ATLANTA TORONTO, CANADA and OTHER AREAS

Miller

MILLER FLUID POWER DIVISION
FLICK-REEDY CO

2006 Hawthorne Ave., Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATO
COUNTERBALANCE CYLINDERS

XU

CORNING GLASS

BULLETIN FOR PRODUCT DESIGNERS

CORNING GLASS WORKS, 52-6 Crystal Street, Corning, New York

Please send me the following material:

- ☐ Booklet: "Glass and You."
- ☐ Bulletin IZ-1: "Glass . . . its increasing importance in product design."
- ☐ Information on the VYCOR brand glasses.

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

How to engineer a platypus

A happy combination of purposeful practicality is the furry platypus with its webbed feet, beaver's tail, and duck's bill.

A lot of our customers, to their continuing delight and profit (we hope), have discovered that glass is sort of platypus-like in that it, too, can be made to combine many useful characteristics.

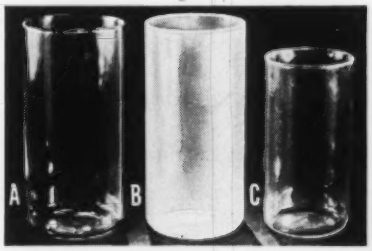
Take, for example, PYREX brand pipe. Here you see a man using a piece of it to drive a one-inch nail in a pine block. This is essentially an extra-curricular activity for glass pipe, which is more at home conveying metal-eating acids around chemical plants, but it's a way of showing just how tough glass can be when it's *made* that way.

All of which may serve to illustrate for you how we can arrange the optical, chemical, thermal, mechanical, and electrical properties of glass in different combinations to match a considerable variety of end-use requirements. In fact, we've worked up some 50,000 different formulas for glass in our years of helping customers solve specific design and processing problems.

If platypus-like glass is a novel idea to you, if you've never given glass a second thought as a highly adaptable design and construction material, we suggest your reading a pocket-size volume entitled "Glass and You." It tells in a few words and many pictures how glass contributes to profit and pleasure and we'd be delighted to send you a copy. Or, if you're more concerned with putting glass to work for you than in learning what it's doing for others, there's a slightly more technical bulletin called, "Glass—its increasing importance in product design." We'll be glad to send you either—or both.

Most remarkable glass

In 1952 Philadelphia's Franklin Institute presented the John Price Wetherill Medal to Corning's Dr. Martin E. Nordberg and Harrison P. Hood for inventing the most fabulous of glasses—VYCOR brand 96 per cent silica glasses.



Evolution of a VYCOR jar: A—formed by conventional glass blowing; B—"thirsty glass"; C—finished product.

These two scientists discovered a composition that appeared to be a combination of two distinct types of glasses. One type could be dissolved out, leaving a skeleton of 96 per cent or more of silica filled with so many millions of holes that a one-inch cube contained some 60,000 square feet of hole surface.

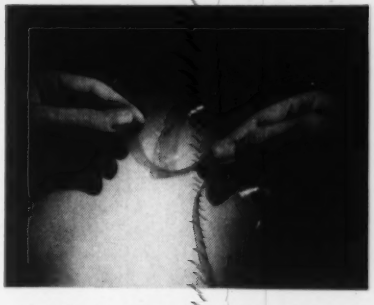
This new child of research was dubbed "thirsty glass" because, just sitting around, it absorbed moisture right out of the air. But our researchers were on the trail of something even more exciting. They heated their "thirsty glass" and it shrank to two-thirds its original size. The millions of little holes vanished and left a vacuum-tight glass that looked like any other—except that you could take this new glass white-hot from a blazing furnace and plunge it into ice water without the slightest injury. It was a glass as ideal as fused quartz, but different since it could be melted, mass produced, and worked in its original state like ordinary glass.

If you'd like to know more, just check the coupon above.

Ribbon glass by the yard

Here's a glass that's a thousandth of an inch thin and in small widths it's flexible as—well, a ribbon. You can twist it, roll it, wrap it around your arm without cracking it. It comes in any length you want—inches, yards, miles.

Actually ribbon glass isn't a single glass. We can make it of several different compositions according to what you need it for. Originally we developed it to take the place of mica in electronic capacitors of which there are several in your radio and TV sets and in any other piece of electronic equipment you can name. As mica is formed in layers, it is subject to cleavage in the plane parallel to lamination; ribbon glass being homogenous is easily workable. This is just one advantage of this glass in capacitors.



Medical scientists have found a quite different use for ribbon glass—as microscope slide covers. These are the wafer-like pieces of glass that are used to cover blood smears and the like for examination under the microscope. In this case ribbon glass can be made clearer, flatter and more free of bubbles and striae than previously made glasses.

Seems as if this unique stuff should be good for a *lot* of things, but *what* (other than electrical and laboratorial) probably lies in the laps of imaginative designers. Would you like us to send you a little strip to play with? *Customer* ideas and problems really bring out the best in glass. So, even if what's on your mind seems unrelated to any item this page discusses, glass may still be its fulfillment. We'd like to hear from you.

CORNING GLASS WORKS

CORNING, N. Y.

Corning means research in Glass

Riveting With a Hammer in Blind or Open Applications

Elimination of special riveting tools can mean faster production, lower costs, no down time.

J. K. BARRY, M. E.

The use of blind rivets installed with only an ordinary hammer from one side of the job offers a highly simplified method of fastening. Speed, convenience and *low installed cost* make Drive Riveting preferable not only for blind joints, but for fastening many parts that can be reached from either side.

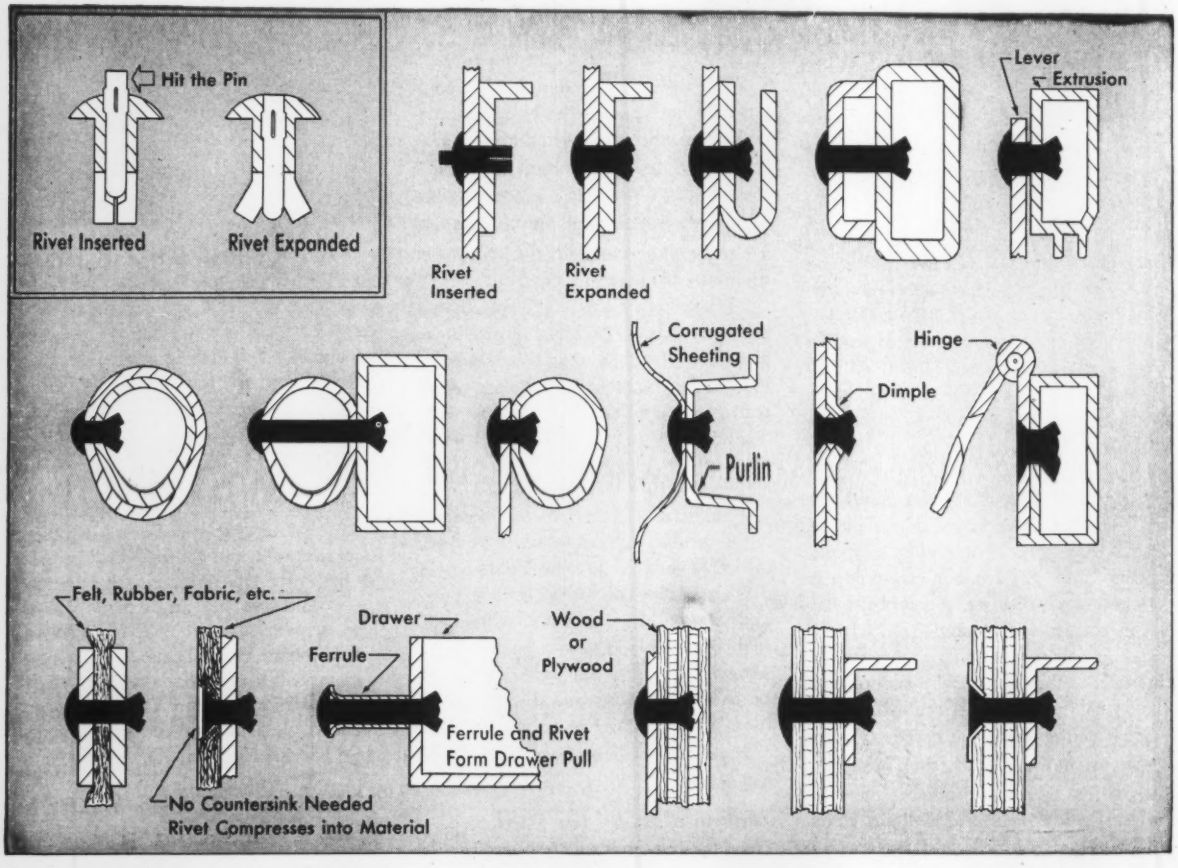
The Southco Drive Rivet has a cored, slotted body with a grooved pin protruding from its head. When the rivet is inserted through parts to be fastened, the pin is driven flush with the rivet head causing the expanding prongs to form a blind head behind the rear sheet. No further finishing is necessary, since the pin seats itself permanently to complete the smooth head contour.

Drive Riveting has five major advantages:

1. No investment in special tooling.
2. No lost time for tool repairs.
3. No limitation on the number of men who can install rivets.
4. Speed comparable to nailing.
5. Only one man is needed.

Widely used in truck bodies, storm doors, metal buildings and hundreds of other industrial applications, Southco Drive Rivets make a secure, vibration-proof joint. A wide range of head styles, diameters and grip lengths is available.

RECOMMENDED APPLICATIONS FOR DRIVE RIVETING



SOUTHCO Division, South Chester Corporation, 237 Industrial Hwy., Lester, Pa.

—ITEM 545—

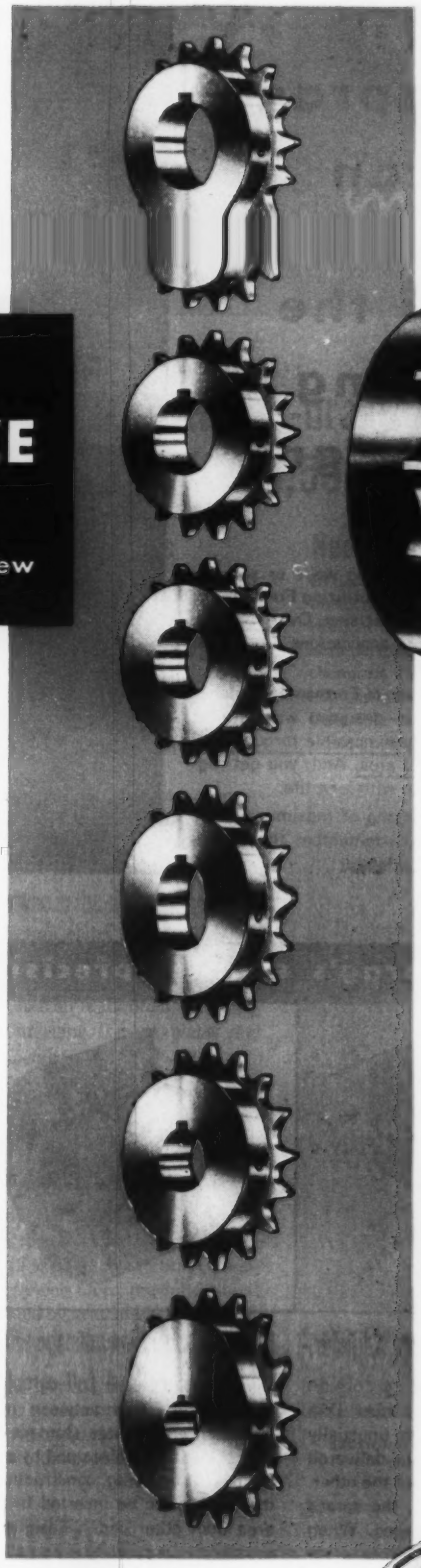
For More Information Circle Item Number on Yellow Card—page 19

NOW! – another cost-saving service from your nearby **BOSTON Gear DISTRIBUTOR**

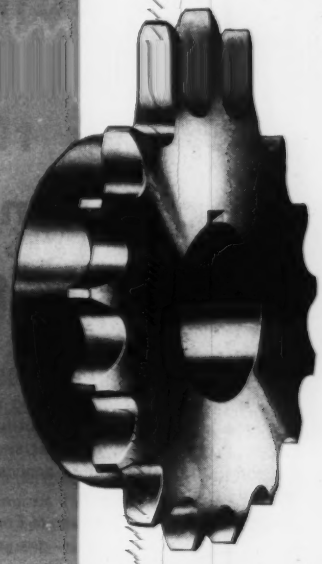
STANDARD STOCK

BORED-TO-SIZE SPROCKETS

complete with Keyway and Setscrew



76 TOOTH SIZES
321 STOCK BORES



"OFF-THE-SHELF" — AT FACTORY PRICES

FINISH BORED – READY TO INSTALL Single width steel sprockets 3/8" Pitch through 1" Pitch—in 76 commonly used Tooth Sizes —with a full selection of finished bore diameters for each sprocket—complete with keyway and setscrew.

ELIMINATE BORING EXPENSE You save expense of reboring, keyway cutting, drilling and tapping for setscrew—and avoid downtime in emergency replacements.

BOSTON GEAR QUALITY Sets the standard for precision and performance—assures longer service life for both sprockets and chain.

OFF-THE-SHELF DELIVERY More than 100 BOSTON Gear Distributors can supply BORED-TO-SIZE Sprockets from stock. Get complete information, on any question of sprocket selection or application, from factory-trained specialists . . . at the Distributor near you. Boston Gear Works, 64 Hayward St., Quincy 71, Mass.

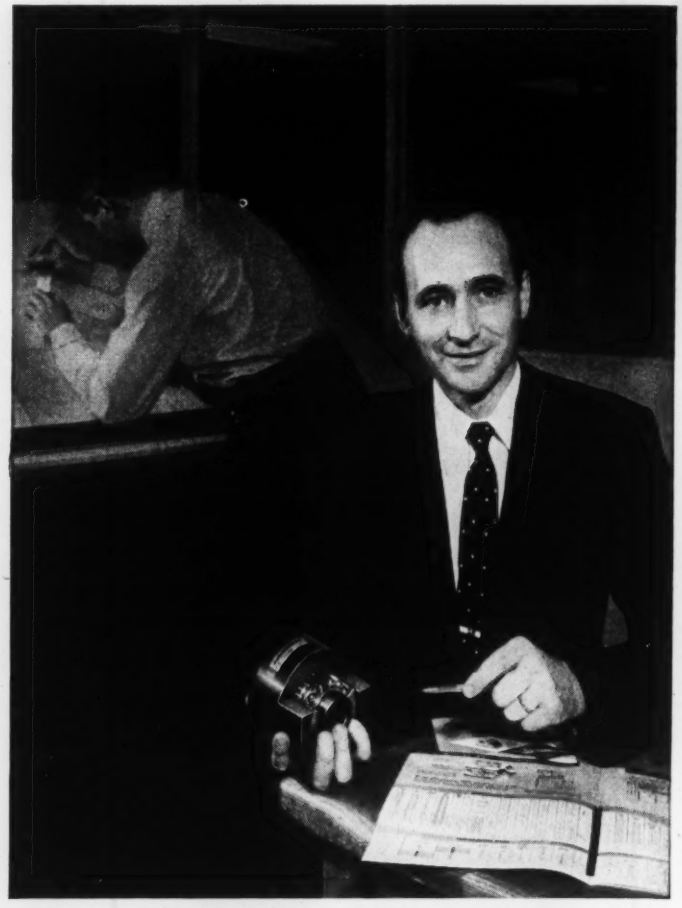
The BOSTON Gear complete line provides any Sprockets you need including SHOLD-A-GRIP interchangeable tapered Sprockets and Bushings. For complete listings, see BOSTON Gear Catalog No. 56.

CALL YOUR BOSTON® Gear DISTRIBUTOR

For nearest Distributor, look under "GEARS" in the Yellow Pages of your Telephone Book.

56BG-S-23

A Formsprag Clutch can simplify the functioning of your design



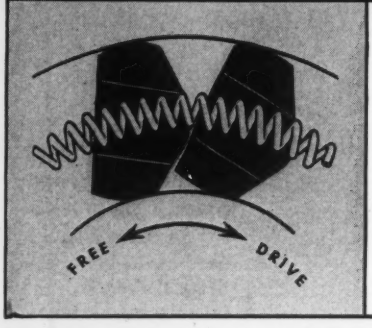
William T. Cherry, Mgr., Formsprag Application Engineering Dept.

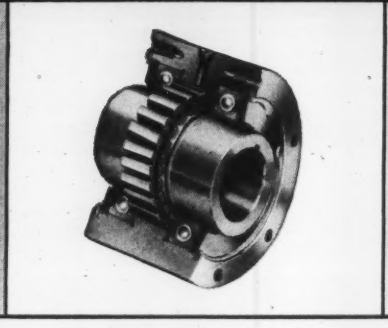
Designers are constantly finding ways to simplify the design of their products by utilizing Formsprag's higher torque capacity and precision. Over-running, indexing, and backstopping applications are almost unlimited.

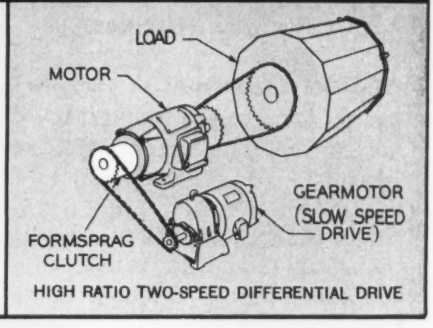
The modern, patented design of Formsprag Clutches is the secret. Each clutch—designed with utmost simplicity—offers the highest possible torque capacity in an extremely small area. And, you get rugged, precision performance with long life.

The next time you're thinking of maximum clutch efficiency for your product—remember these principles about Formsprag Clutches:

How Formsprag's simple, precision design works for you







HIGH RATIO TWO-SPEED DIFFERENTIAL DRIVE

Sprags used in Formsprag Clutches are highly developed, precision wedges of hardened alloy steel. Due to the sprag's design, an unusually high amount of torque is delivered from one concentric race to the other. When torque is applied, the sprags are instantaneously engaged. When torque is removed, the sprags release instantaneously.

Basic construction of the Formsprag Clutch is simple. A full complement of sprags is inserted between inner and outer concentric races. Contact with both race surfaces is maintained by energizing springs. Formsprag construction allows more sprags to be inserted in a smaller area than other clutch designs. Result: greater torque capacity in a smaller clutch.

Here is a typical over-running arrangement on a two-speed drive: The clutch transmits power during the low speed cycle while the high speed motor acts as a countershaft and transmits power to the load. During the high speed cycle, the over-running clutch permits the low speed motor to be over-run. This arrangement is particularly economical and efficient where the speed differential required is too great for a two-speed motor.

Formsprag's engineering department has solved literally thousands of clutch application problems—using either standard or specially designed clutches. For further information, send for this informative eight-page brochure or contact Formsprag direct.

A7-43

Distributors in Principal Cities

FORMSPRAG Company

23603 Hoover Road, Van Dyke, Michigan

World's Largest Exclusive Manufacturers of Over-Running Clutches

—ITEM 547—

For More Information Circle Item Number on Yellow Card—page 19

Facing Page—ITEM 548→

DU PONT ELASTOMERS

in Design

HYPALON® can be compounded in an unlimited range of weather-resistant colors

HYPALON, Du Pont's new synthetic rubber, brings brilliant and varied colors as well as superior performance to the design field. Colored compounds of HYPALON start bright . . . *stay* bright despite severe exposure conditions indoors or outdoors. The samples shown above, for example, were subjected to two years of outdoor exposure. There is virtually no change in color and negligible change in physical properties.

In addition to outstanding color stability, HYPALON has many other advantages that can help your products give *extra-long service* on industry's toughest jobs. Compared to other kinds of rubber, HYPALON shows unusual resistance to hardening at elevated temperatures (250° to 350°F.). It is completely resistant to ozone and has exceptional resistance to strong oxidizing agents.

When your design calls for a resilient material that must have exceptional resistance to these conditions, it will pay you to take a close look at HYPALON.

NEOPRENE air-brake tube still in service after 5,500,000 flexings

No downtime in 4 years

The brake element shown is part of a clutch-and-brake unit which is capable of stopping heavy rotating equipment within 1/10 of a second. One such unit has piled up a record of 5,500,000 engagements in four years *without any maintenance*. The key to this kind of performance lies in the design of the machine and in the use of two rayon-reinforced neoprene tubes.

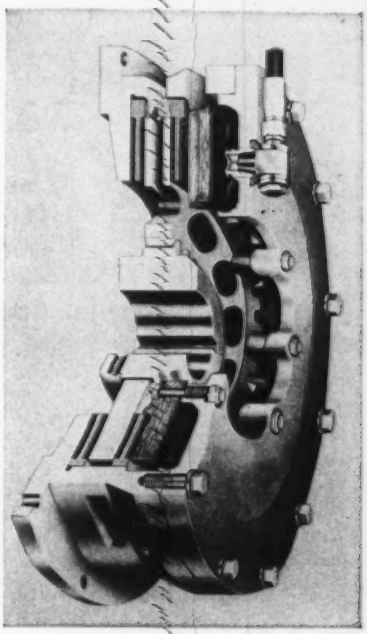
Typically, two of the pictured elements are used together, one serving as the clutch, the other as the brake. When the stop switch is thrown, compressed air is released from the neoprene tube in the clutch element; this disengages friction plates in the clutch and disconnects the drive motor from the driven machine. At the same time, in the brake element, compressed air is admitted to the neoprene tube, engaging friction plates and halting the machine.

Neoprene resists oil, high temperatures

Neoprene's superior oil resistance and durability at high temperatures have made the performance of this clutch and brake possible. Natural rubber tubes previously used were deteriorated by heat and by the oil that almost invariably gets into any compressed-air supply. They swelled, and the inside surfaces tended to become tacky and stick together. When rayon-reinforced neoprene air tubes were used, the problem was solved.

Neoprene makes a better design

In designing new products or improving old ones, neoprene stands up where ordinary resilient materials fail. Neoprene offers the designer resistance to oil, heat, weathering, chemicals and abrasion. It improves product performance—cuts maintenance costs. Complete property data and typical neoprene application data are available.



SECTIONAL VIEW of brake element, with Neoprene air tube in red

DU PONT
REG. U.S. PAT. OFF.

HYPALON *is a registered trademark of E.I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

Please send further information and add my name to the mailing list for your free publications, the "Neoprene Notebook" and "Facts about HYPALON®," which show how the Du Pont elastomers are used in designing new products, improving old. I am particularly interested in

_____

_____

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, Dept. MD-6
Wilmington 98, Delaware

Name _____ **Position** _____

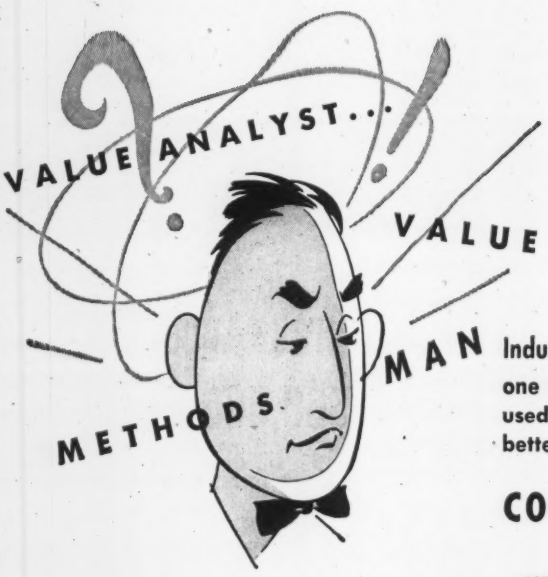
Firm _____

Address _____

City _____ **State** _____

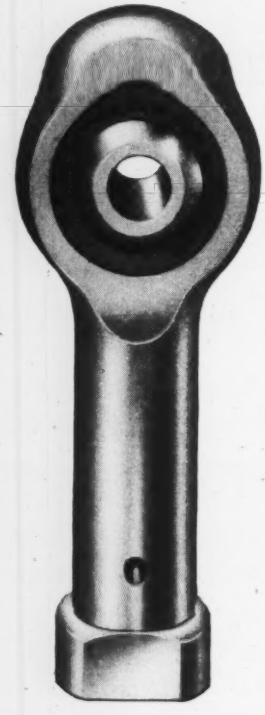
THE SURPRISINGLY VERSATILE

HEIM *Unibal*

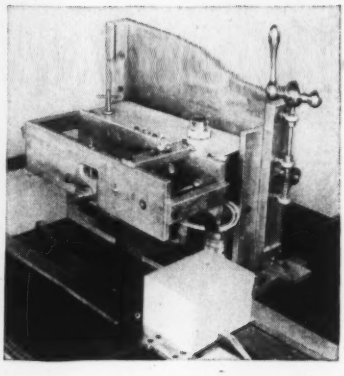


Industry's newest specialist has many names, but just one purpose — to study parts, materials, or methods used in manufacturing, with an eye toward getting better quality or performance at lower cost.

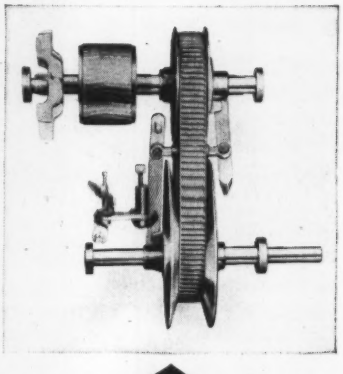
CONSIDER the possibilities of unusual adaptations of the . . .
HEIM *Unibal* SPHERICAL BEARING ROD END



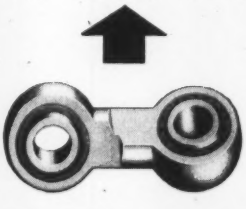
IDEA On the Van Buskirk marking machine, there is a crank, shaft, worm gear, and pinion for raising and lowering printing drums. As an easy-to-install support for this shaft, three Heim Unibal Rod Ends were attached to the frame by simply drilling holes and fastening from the back with ordinary hex-head bolts. While the self-aligning feature of Heim Unibal was not essential at this point, the low cost and simplicity of the mounting made them ideal for these supports.



IDEA Put 2 Heim Unibals in a double-end offset link, such as was done in the Sterling "Speed-Trol" Vertical Mounted electric motor, and you have a smoother operation than could be obtained with specially machined, high cost part and without resorting to weldments or other time- or labor-consuming operations. This double end construction is not a stock item to be sure, but it demonstrates the possibilities of improved operation with the Heim Unibal.



There are no set rules to say that a rod end can only be used as a bearing at the end of a push-pull rod — consider the versatility of the Heim Unibal, whose applications are practically unlimited.



MALE AND FEMALE SIZES ARE LISTED IN THE COMPLETE CATALOG OF HEIM BEARINGS.

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT

HAS MANY USES OTHER THAN STRICTLY ROD END APPLICATIONS

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 27

3 Year Test Proves Superiority Of Silastic Gaskets On Steam Cookers

Despite prolonged exposure to steam and pressure, Silastic*, Dow Corning's silicone rubber, keeps its shape, remains resilient, maintains an efficient seal. That's why the Cleveland Range Co. uses gaskets made from Silastic for sealing the doors of its well-known line of Steam-Chef Steam Cookers.

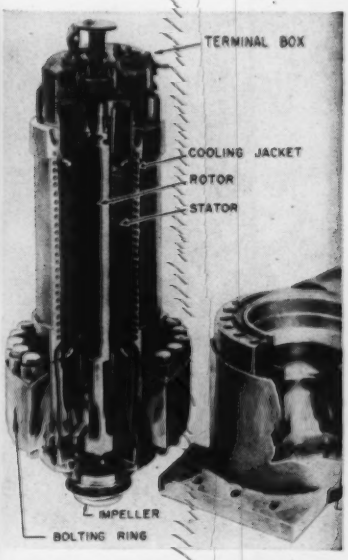
The change from organic rubber to Silastic was made after a three year field test program which proved the superiority of silicone rubber gaskets. Molded by the Ohio Rubber Co., these test gaskets were installed on Cleveland Range units in commercial and institutional kitchens throughout the midwest.

Restaurant managers were surprised to see at the end of six months, the average life of organic rubber gaskets, that the Silastic gaskets still looked as good and sealed as efficiently as when new. Time and rugged service apparently had little or no effect on the silicone rubber gaskets. Particularly impressive was the fact that Silastic did not absorb food oils or impart off-flavor taste to foods during cooking.

This photograph of a Steam-Chef Cooker in the Mill Restaurant, Cleveland, Ohio, shows the type of evidence compiled during this test. The

(cont'd. pg. 2)

* T. M. REG. U. S. PAT. OFF.



CANNED MOTOR-PUMP HANDLES RADIOACTIVE LIQUID COOLANTS

Utilizing the thermal stability of electrical insulation made with Dow Corning silicones, Westinghouse designers have developed a canned motor-pump that answers the Atomic Energy Commission's need for a way to circulate radio-active liquid coolants at temperatures up to 650 F in hermetically sealed hydraulic systems.

Used in the primary coolant system of nuclear reactors, both the pump impeller and its electric drive motor are encased in a single pressure-tight vessel. The hot, radioactive fluid circulates around the bearings, rotor and stator of the silicone insulated drive motor.

Stainless steel jacketing protects the ends and outside diameter of the stator windings. A thin, leak-tight, nickel-alloy cylinder or "can" lines the inner bore of the stator. The outer surface of the rotor is similarly canned.

Silicone-insulated canned motor-pumps of this design are now available in capacities

(cont'd. pg. 2)

Liquid Springs Use Silicone Fluid For Greater Efficiency

With compressibility of 9 to 10% at 20,000 psi compared to 6 or 6½% for mineral base oils, silicone fluids are specified by designers at Wales Strippit Corporation as the compressible media for their entire line of liquid filled "Hydra Springs."

Thermal stability and remarkably flat viscosity temperature slopes were also important considerations which led to the use of Dow Corning silicone fluids in these precision hydraulic devices. Most Hydra Springs employ Dow Corning 200 Fluid. A few, requiring special springing characteristics, utilize other Dow Corning silicone fluids.

Providing forces 3 to 6 times greater than coil springs of equal size, Hydra Springs have proved highly efficient and successful in metal working, dies, perforating equipment, testing equipment, ordnance devices, specialized machinery. *No. 268*

Liquid spring at right delivers same amount of force as the large cumbersome metal coil spring.

CLASS H MOTOR STILL ON TEST AFTER 56,715 HOURS AT 240 C

At 10 A.M., June 6, 1946, a Class H insulated 5 hp motor was generator loaded to operate at its test temperature of 240 C in Dow Corning's motor test labs. Every 500 hours since it has been shut down and exposed to 100% relative humidity for 24 hours. As of 11 A.M. May 1, 1956, this motor was still on test after 56,715 hours at an average copper temperature of 240 C! That's equivalent to 344 years operation at the Class H temperature of 180 C.

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .

Dow Corning Z-4141, an easily applied silicone treatment for glass surfaces, imparts a high degree of scratch resistance and reduces breakage. Effective at low concentrations on bottles and containers, light bulbs and tubing, camera lenses, and artware. *No. 273*

"Potting Gives Maximum Reliability", an article from ELECTRONIC EQUIPMENT, describes the method of encapsulating a new series of electronic devices developed by the Naval Ordnance laboratory. Using silicones helps to provide the utmost protection against mechanical and thermal shock, vibration, and humidity. *No. 274*

Now available—1956 Reference Guide to Dow Corning Silicone Products. A concise, comprehensive, 12-page reference that is convenient-to-use. It's packed with data, properties, and information on how you can use silicones in designing new equipment, improving performance and reliability of original equipment, or reducing production and maintenance costs. *No. 275*

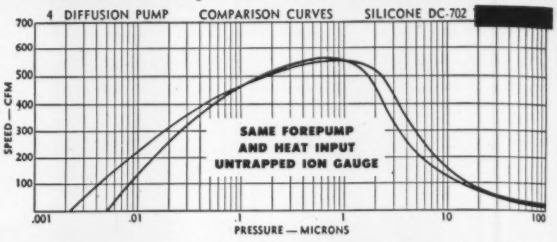
Silicone-Glass Laminates for electrical and mechanical applications are described in new brochure which illustrates parts used in typical industrial applications. Also lists engineering information on properties of silicone-glass laminates and lists fabricators of such laminates. *No. 276*

Dow Corning 510 Fluids are unsurpassed as damping media for instruments and other devices required to give uniform performance from —70 to over 400 F. Excellent dielectric properties plus relatively constant viscosities make these silicone fluids particularly adaptable to electrical and electronic equipment. *No. 277*

Documentary film "What's a Silicone?" available free of charge for showings to technical audiences in every industry. In full color and sound, this dramatic 16mm film allows you to see Dow Corning silicones in action improving the performance of products ranging from nursing bottle nipples to diesel locomotives. For more information about this educational film and how to arrange a showing for interested persons in your plant, circle ..... No. 278

Speed And Range Of Vacuum Pump Increased With Silicone Fluid

A series of tests conducted by the F. J. Stokes Machine Company, Philadelphia, world's largest producer of high vacuum equipment, prove that Dow Corning 702 Diffusion Pump Fluid helps to attain higher vacuum in less time than possible with organic fluids.



As indicated by the curve, the silicone fluid provides faster evacuation in the 1 to 10 micron range and at the same time assures lower ultimate pressures in the range between .01 and .001 microns.

The tests were performed in connection with development of Stokes' new line of Ring-Jet Diffusion Pump Series 160, and Ring-Jet Booster Pumps Series 150. Remarkably effective for rapid-cycle work, these pumps are available in 5 sizes from 4 to 16 inches.

The test results, since confirmed by experience in other Ring-Jet Pump models, have led Stokes to advise its representatives "since the organic fluid is almost the same in price as the silicone, the silicone fluid (Dow Corning 702) would be preferable, especially considering that it will not oxidize when subjected to the atmosphere at high temperatures." *No. 271*

Silastic Impregnated Sleeving Insulates Lead Wire in Strip Heater

Braided glass sleeving impregnated with Silastic, Dow Corning's silicone rubber, retains excellent flexibility and insulating effectiveness at temperatures that cause rapid failure of organic electrical insulating materials. The advantages of such sleeving are demonstrated in the small strip heaters manufactured by Watlow Electric Co., of St. Louis.

Not much larger than elbow spaghetti, these efficient 175 watt heating units are used by aircraft builders and other metal working companies to heat aluminum during dimpling or countersinking to provide flush mounting of rivets. Most aluminum alloys cannot be formed cold without setting up stresses.

Slipped over the dimpling die-tips, the heaters produce temperatures of 500 F and higher. The lead wires flex continually with movements of the die. To protect the lead wire with a high dielectric strength material that retains good flexibility at high temperatures, Watlow uses Turbo 117, a Silastic impregnated sleeving fabricated by The William Brand Co. Watlow reports silicone insulated sleeving has substantially reduced lead wire failures. No. 272

MOTOR-PUMP *(continued)*

from 5 to 17,000 gpm. They can handle high temperature liquids at system pressures up to 2500 psi.

According to Westinghouse, these pumps are also used in steam systems where controlled or forced circulation is required, and in certain process applications of the chemical and petroleum industries. Special canned motor-pumps are even available for pumping molten metal at temperatures as high as 1000 F. *No. 269*

COOKER GASKET *(continued)*

organic rubber gasket on lower door, hardened and flattened by heat and pressure, has completely lost its sealing efficiency. The narrow Silastic gasket on the top door is as effective as new after the same length of service. No. 270

Dow Corning Corporation, Dept. 6804, Midland, Michigan

Please send me: 268 269 270 271 272 273 274 275 276 277 278

NAME _____

TITLE _____

COMPANY _____

STREET _____

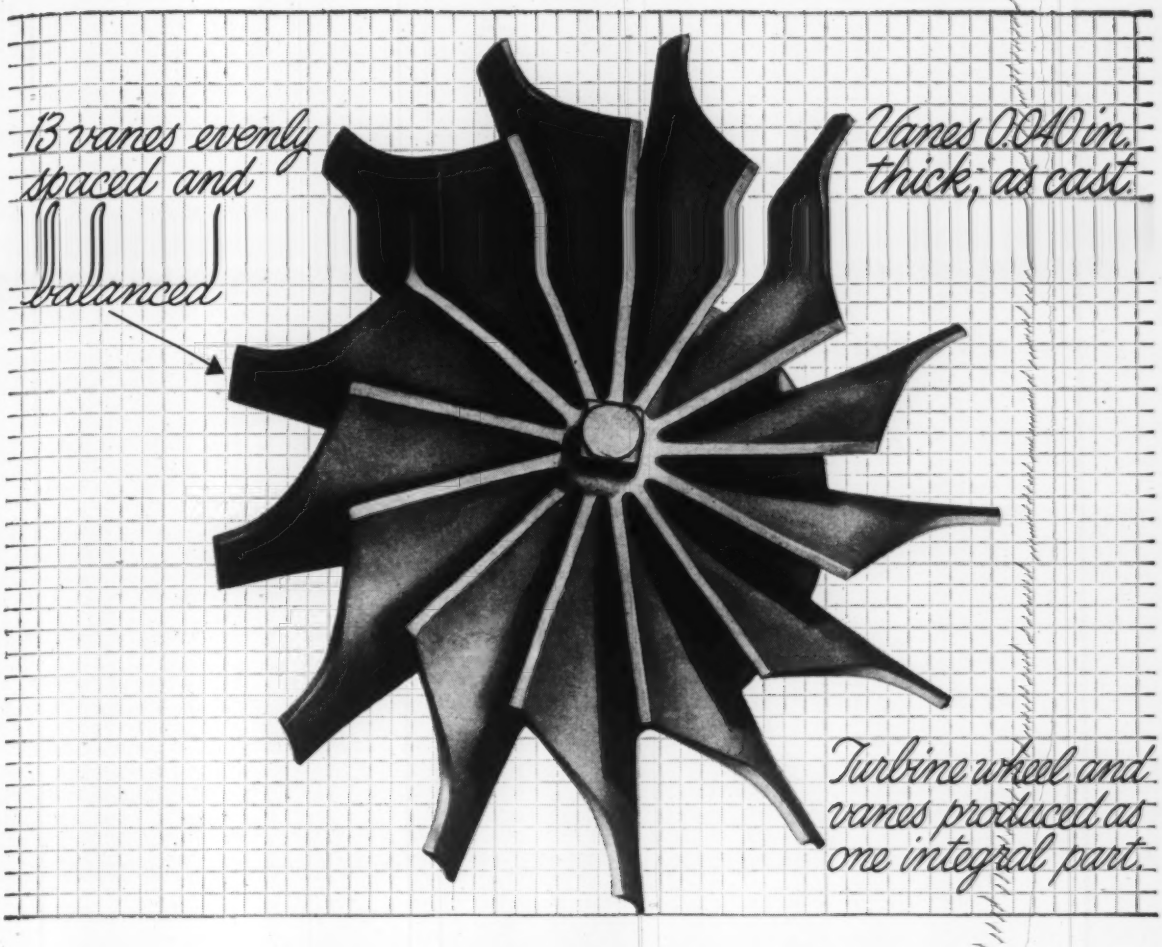
CITY _____ ZONE ___ STATE _____

SILICONE NEWS is published for product design and development engineers by

DOW CORNING CORPORATION
MIDLAND MICHIGAN

first in silicones
DOW CORNING SILICONES

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS DETROIT LOS ANGELES NEW YORK WASHINGTON, D.C. (SILVER SPRING, MD.)
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS



Tough Design Problem Solved by Investment Casting....

The precision-investment-casting process proved to be the most practical and economical way to produce an efficient turbine wheel for a diesel engine supercharger. The wheel rotates at 42,000 rev. per min. and is exposed to a 1450-deg. F. temperature. It had to be made of a hard-to-machine alloy capable of standing up under these severe service conditions. Yet, to operate efficiently, the vanes of the wheel had to be extremely thin and formed to an intricate shape.

The vanes and wheel were produced as one integral part by HAYNES' precision-investment casting process. Only two simple finishing operations were needed to put the wheel in service. The vanes are only 0.040 in. thick . . . too thin to produce by other methods without a prohibitive amount of machining on a hard, tough alloy.

The successful production of this turbine wheel points up one of the big advantages of HAYNES' precision-investment casting process . . . the planning freedom it offers to design engineers. For the full story on how this modern mass-production method can help you, contact one of the District Sales Offices listed below.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works: Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation.

—ITEM 551—

For More Information Circle Item Number on Yellow Card—page 19

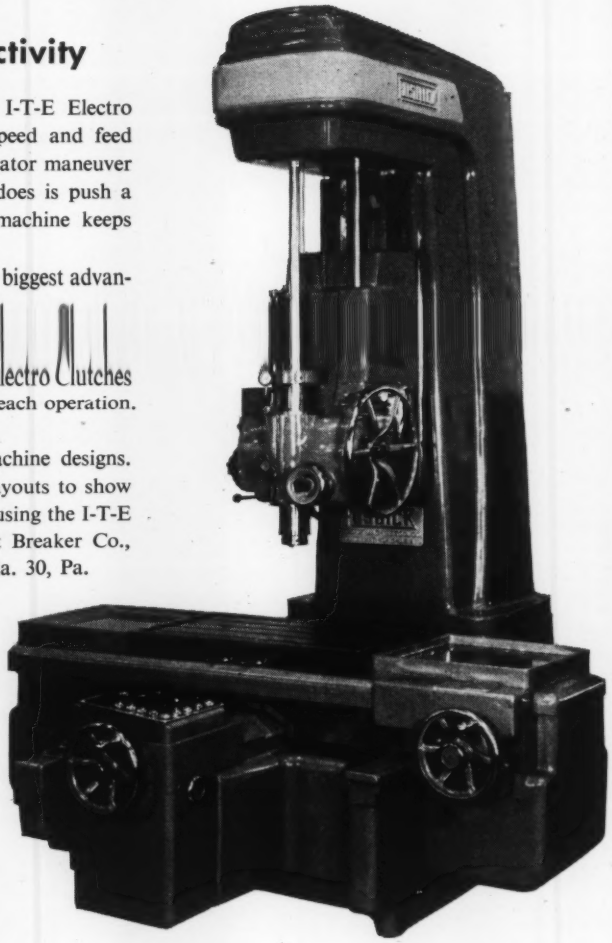
I-T-E ELECTRO CLUTCHES MAKE POSSIBLE SPEED AND FEED CHANGES IN 1/2 SECOND

Easier operation boosts productivity

The Fosdick Machine Tool Co. has now incorporated I-T-E Electro Clutches into its precision jig borers. Formerly every speed and feed change meant the machine had to be stopped and the operator maneuver a mechanical slide-gear shifting mechanism. Now all he does is push a button on the conveniently located control panel. The machine keeps running; keeps producing.

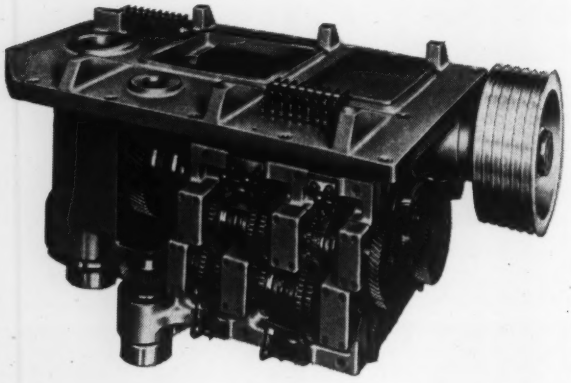
Easier operation and increased production—these are the biggest advantages that I-T-E Electro Clutches can add to machine tools. Electro Clutches make it easier to operate machines at their best speeds for each operation. In addition, they have transmission gear space.

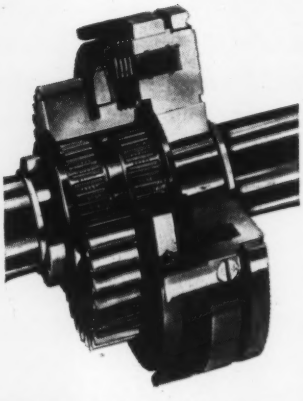
I-T-E Electro Clutches are available to fit existing machine designs. I-T-E application engineers will be glad to help prepare layouts to show you the space-saving possibilities and ease of control when using the I-T-E Electro Clutches. Write for Bulletin #5306. I-T-E Circuit Breaker Co., Transformer-Rectifier Division, 19th & Hamilton Sts., Phila. 30, Pa.



FOSDICK PRECISION JIG BORER
MODEL H-1015

SPACE SAVER. Complete transmission for the Fosdick machine. Notice compactness and simplicity for mounting I-T-E Electro Clutches on same shafts with gears. Clutches operate right in housing with oil lubricant.





NO ADJUSTMENTS. The I-T-E Electro Clutch is simple, compact, requires no adjustments for wear. Available in torque ratings from 3.2 ft. lb. to 45,000 ft. lb.

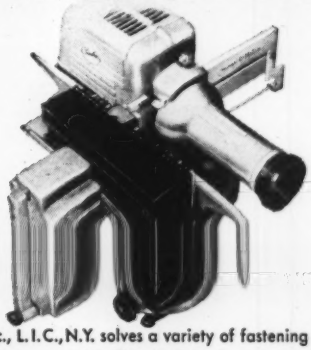
I-T-E

I-T-E CIRCUIT BREAKER COMPANY • Transformer-Rectifier Division

—ITEM 552—
For More Information Circle Item Number on Yellow Card—page 19

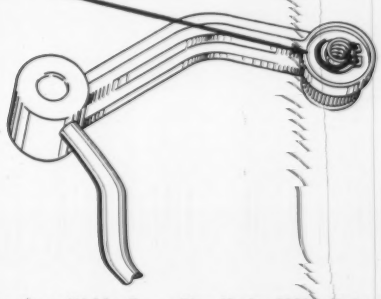
Waldes Truarc Rings Permit Better and More Economical Design—Fewer Parts, Faster Assembly, Minimal Rejects!

Viewlex's Change-O-Matic



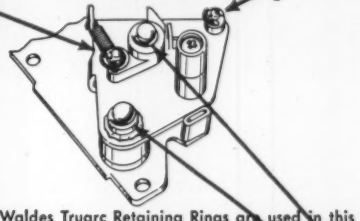
Viewlex, Inc., L.I.C., N.Y. solves a variety of fastening problems in their new model Change-O-Matic automatic slide changer. Assembly time is speeded, parts eliminated, rejects lowered, and compact, economical product design achieved.

Connecting Arm Assembly



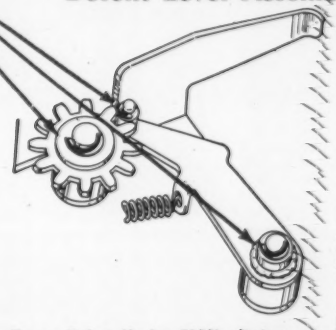
Use of one Waldes Truarc Ring (Series 5108) eliminates time-consuming riveting over the flange, retains and holds the connecting knob captive. A compact, neat design is made possible, rejects caused by poor riveting eliminated.

Actuating Plate and Pawl Assembly



Three types of Waldes Truarc Retaining Rings are used in this assembly. One circular self-locking ring (Series 5105) retains pawl return spring. One external E-ring (Series 5133) retains roller used to prevent gear motion during transport cycle. One crescent ring (Series 5103) retains pawl which indexes gear. Second crescent ring retains sub-assembly. Truarc Rings speed assembly, cut rejects, eliminate parts.

Detent Lever Assembly



Truarc E-ring (Series 5133) eliminates use of tapped hole and shoulder screw, retains roller which prevents over-travel of gear. Assembly is rapid.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!

Send for new catalog supplement

WALDES TRUARC® RETAINING RINGS

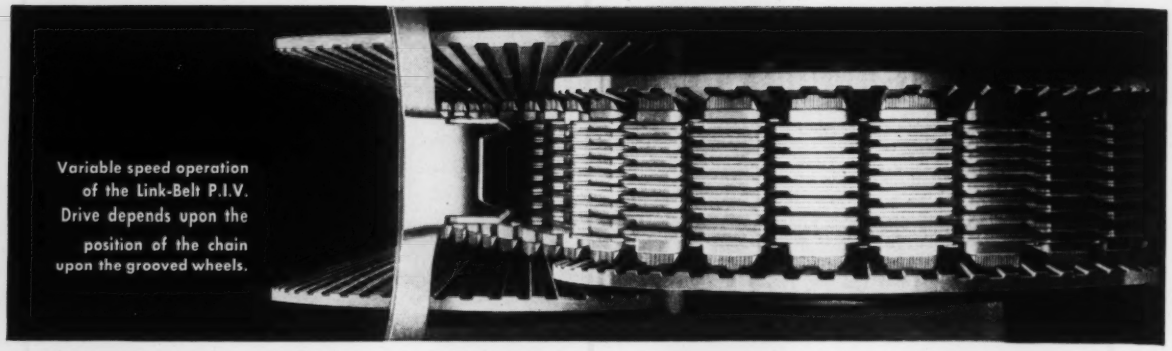
Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

*Name*_____
*Title*_____
*Company*_____
*Business Address*_____
*City*_____ *Zone*____ *State*_____

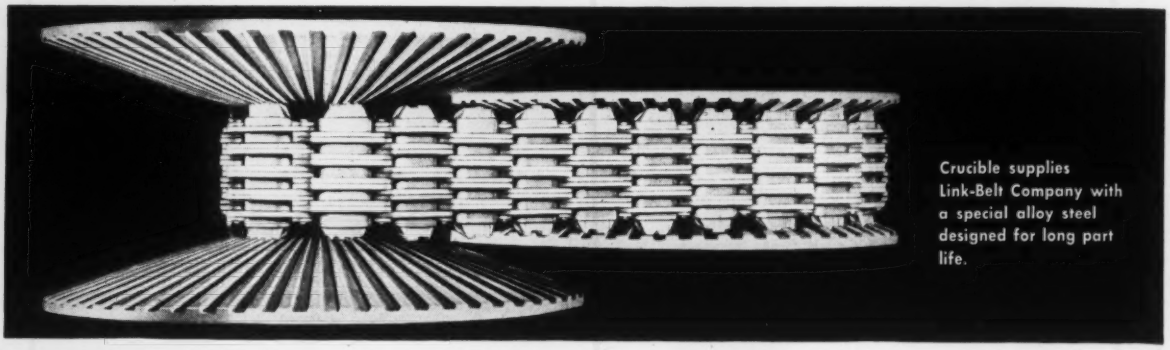
MD 088

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

—ITEM 553—



Variable speed operation of the Link-Belt P.I.V. Drive depends upon the position of the chain upon the grooved wheels.

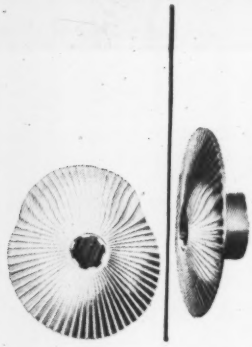


Crucible supplies Link-Belt Company with a special alloy steel designed for long part life.

these

SPECIAL ALLOY STEEL PARTS

keep Link-Belt's P.I.V. Drive on the job



Keeping production operations going at the right speed is the job of this variable speed drive unit produced by Link-Belt Company. Its operation is based on an exclusive drive chain with self-forming metal teeth, which engage with radial grooves in two pairs of cone-shaped wheels.

To make these precision wheels requires a steel that can be readily machined, will not distort, and which has high-strength. That's why Crucible furnishes Link-Belt with a special Nitriding BM alloy steel *designed* for this application. After machining the wheels are Nitrided to obtain a minimum surface hardness of 1000 Vickers Diamond Brinnel – about the hardest surface that can be obtained commercially.

When your application requires a tough, machinable, nondeforming alloy steel – call Crucible. One of our many special alloy grades may be the right one for you – or we can develop one to meet your most exacting demands. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

—ITEM 554—

For More Information Circle Item Number on Yellow Card—page 19

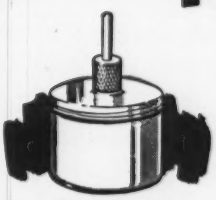
You name it—MOYNO® pumps it!

Foods

Potato salad, chow mein, peas, cream-style corn, tomatoes, molasses, chocolate.

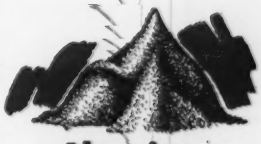
Chemicals

Caustics, acids, dyes, petroleum solvents, soaps, sludges, latex, synthetic resins.



Pastes

Paper coating, starch, seam paste, size, adhesive dope, heavy grease, graphite sludge.



Abrasives

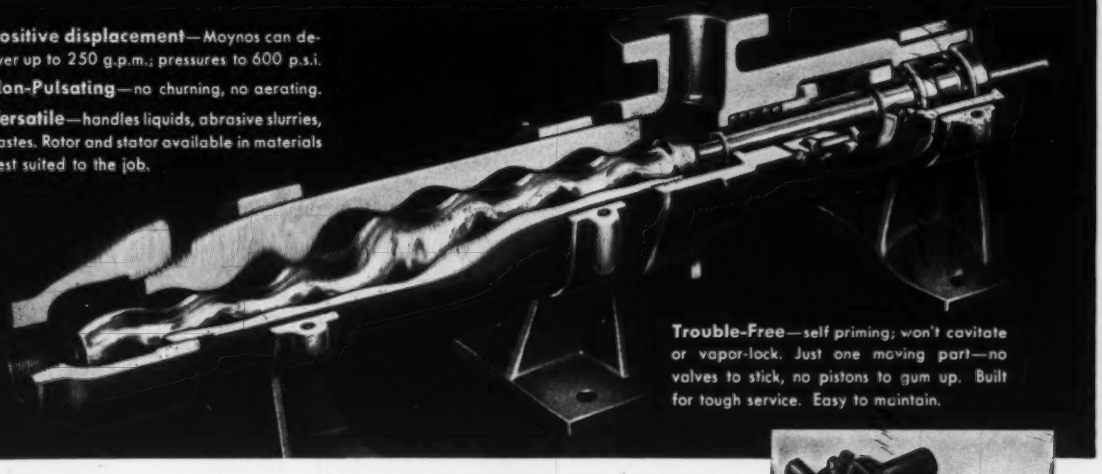
Insulator clay, frit, ground glass and water, porcelain glaze and enamel, cement, plaster.

FEATURES OF THE MOYNO THAT MAY SOLVE YOUR MATERIALS-HANDLING PROBLEM

Positive displacement—Moynos can deliver up to 250 g.p.m.; pressures to 600 p.s.i.

Non-Pulsating—no churning, no aerating.

Versatile—handles liquids, abrasive slurries, pastes. Rotor and stator available in materials best suited to the job.



Trouble-Free—self priming; won't cavitate or vapor-lock. Just one moving part—no valves to stick, no pistons to gum up. Built for tough service. Easy to maintain.

R & M Moynos handle almost anything that can pass through a pipe

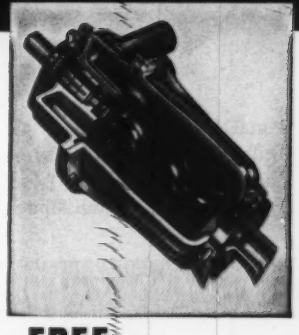
The Moyno is a problem-solving pump. And whether your problem is one of materials, maintenance or flow, there's a better-than-even chance that the Moyno is the pump you're looking for.

Here is a completely different kind of pump that handles almost anything that will push through a pipe, from free-flowing liquids to non-pourable pastes—even materials containing relatively large particles or abrasives.

This is how the Moyno works: a screw-like rotor turning within a double-threaded stator creates cavities which *progress* toward the discharge end of the pump, carrying the material being handled. The result is a smooth, steady flow, free from pulsation and turbulence.

The pumping elements of the Moyno are available in a wide range of materials, depending upon the substances to be pumped. From stainless steels and synthetic rubber to tool steels, bronze, plastics—there is a Moyno that will do the job you want, and do it with remarkable efficiency.

Industrial-type Moynos are available with capacities to 250 g.p.m.; pressures to 600 p.s.i. Small Moynos (see inset), used as original equipment, serve on washers, water pumps, sprayers, and many other products.



FREE...

this informative bulletin

Tell us your pumping problem—let's see how the Moyno can help solve it. If necessary, we'll be glad to run tests for you in our own laboratories. In any case, get the details on the Moyno—mail the coupon below.

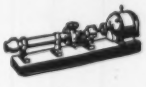
ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

Fractional and Integral HP Motors

Desk, Window, and Household Fans

Hoists and Cranes



Moyno Pumps

Propellair Industrial Ventilating Equipment

Robbins & Myers, Inc.
Pump Division, Springfield, Ohio (MD)

Please send Bulletin 30C on Moyno Pumps

Name _____ Title _____

Company _____

Address _____

City _____ State _____

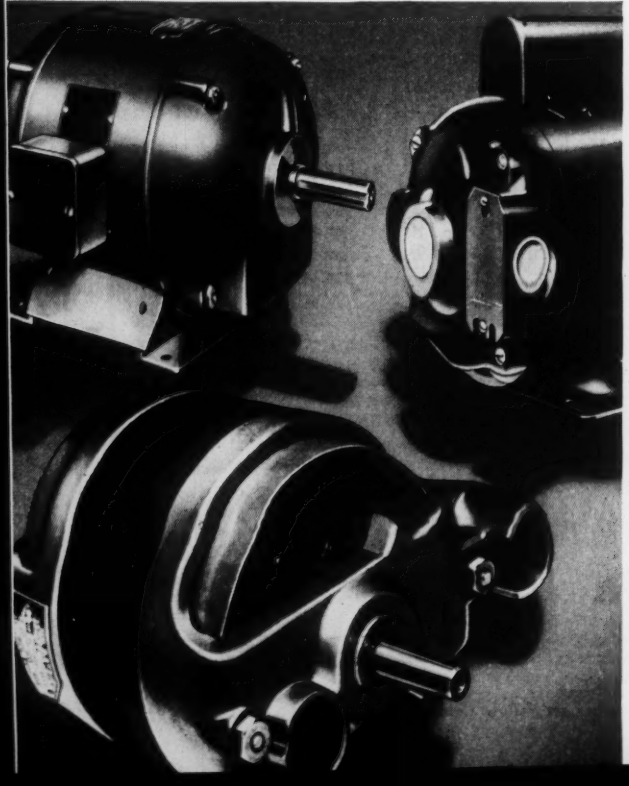
—ITEM 555—

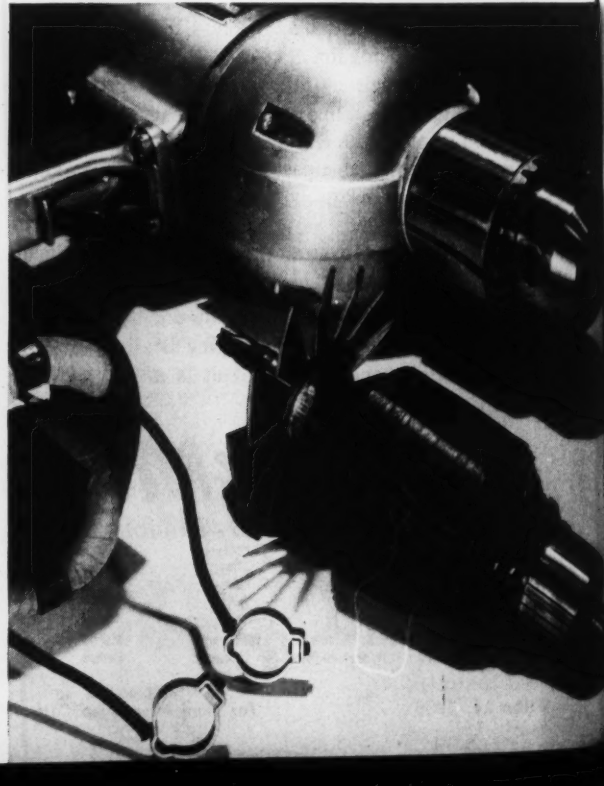
Complete Motors...
...or Motor Parts

Let your *design problem* make the choice!

Standard motors and matched motor parts represent only the beginning of what R & M is qualified to build! Special R & M fractional-horsepower motors with *any* housing design—or specially designed motor parts to fit your housings—are regular R & M contributions to products such as those listed below:

- Portable Saws
- Drills
- Nut Setters
- Hammers
- Routers
- Screw Drivers
- Hedge Trimmers
- Lawn Mowers
- Nibblers
- Lock Mortisers
- Valve Grinders
- Vacuum Cleaners
- Fans
- Sanders
- Pumps
- Compressors
- Hones
- Business Machines
- Cast Cutters
- Food Mixers
- Polishers
- Planers
- Portable Grinders
- Sirens
- Advertising Devices
- Ventilating Equipment
- Oil Burners
- Surgical Instruments
- Grease Guns
- Vibrators
- Die Sinkers
- Waxers





19 MUSCLES

for an electronic super-brain!

With the help of R & M Motors, the new IBM Electronic Data Processing Machine solves in 7 minutes a problem that would take 7 years with an ordinary desk calculator.

Imagine adding and subtracting 16,666 times per second; multiplying and dividing 2,192 times per second; "remembering" stored factors in 12 millionths of a second! That's what the IBM electronic computer means as a time-saver for industry.

If *you* have motors in your products, there's another significant fact about this outstanding development: *Robbins & Myers built 19 motors for use in this machine.*

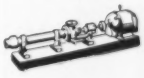
Leading producers of motor-driven tools, machines and appliances recognize R & M as the *one* source that makes a specialty of building *exactly* the motor needed. Of course, if a standard R & M motor will do the job—fine. We build thousands of them. But, we also *custom-design* motors to your requirements. In short, the recommendations of R & M engineers aren't prejudiced by any limitations of stock designs . . . you don't have to compromise with what's *right.*

If you have a motor problem . . . or a new product design on the boards . . . write us today. Any details you give us about your problems will help us to give you more specific recommendations. They will be held in confidence, of course.

ROBBINS & MYERS, INC.

MOTOR DIVISION: SPRINGFIELD 99, OHIO • BRANTFORD, ONTARIO

Fractional & Integral h.p. Motors & Generators


Moyno Pumps

Propellair Industrial Ventilating Equipment

Electric Fans

Electric & Hand Hoists & Cranes

R & M MAKES BOTH!

Fractional-horsepower motors and parts . . . from 1/200 h.p.

If it's an **R&M**, *it's the Right Motor!*

Integral-horsepower motors; famous R & M "All-Weather"* with sealed bearings. Up to 200 h.p.

**"All-Weather" is an R & M trademark*

This coupon will bring you prompt information. MD

Robbins & Myers, Inc., Motor Division, Springfield 99, Ohio

Please send me, without obligation, information on:

- ☐ Motor Parts for Portable Tools
- ☐ Universal Motors
- ☐ Capacitor Motors
- ☐ R & M "All-Weather" Motors —up to 200 h.p.
- ☐ Please have a Motor Specialist call

Product we manufacture: _____

Name _____

Title _____

Company _____

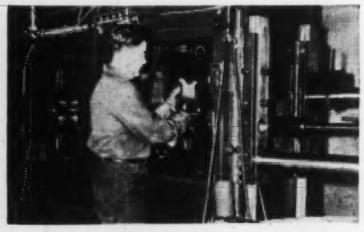
Street _____

City & State _____

New trends and developments in designing electrical products . . .

Why General Electric Magnets clad in die-cast aluminum sheaths offer important design and cost advantages over the conventional methods of fabricating magnetic assemblies

THE MAN in the picture below is removing a section of a radar magnetron tube magnet from a piece of equipment that goes by the imposing title of "Lester-Phoenix Horizontal Cold Chamber H-HP-3X 400-Ton Die-Casting Machine."



This machine is in our Edmore, Michigan, magnet plant, and its sole function is to cast aluminum sheaths on General Electric Alnico Permanent Magnets.

These alclad magnets offer designers seven major advantages over conventional methods of fabricating magnetic assemblies.

1. Die casting strengthens the magnet structurally.
2. Whole assemblies can be designed and built as a single "package," speeding the final assembly job at the plant.
3. Design of mounting arrangements is simplified because pins, holes, and screws can be cast into the sheath, instead of the magnet.
4. Responsibility for the entire assembly is centered in a single source, simplifying purchasing procedures, and eliminating costly in-plant assembly operations.
5. Complete magnetic assemblies can be purchased premagnetized and/or pretested.
6. Die casting provides a consistent, more attractive finish for applications where appearance is important.
7. Die casting is a convenient, low-cost mass-production technique for magnetic assemblies that eliminates the problem of attaching crystalline cast magnets to other components.

The following examples will illustrate how these advantages can be turned to practical use.

Figure 1 is a relay drag magnet assembly, typical of those used in the meter and instrument industry. Before the manufacturer switched to this casting, it was necessary to cast a magnet against a piece of steel, bend the steel into the proper shape, and weld the ends together.

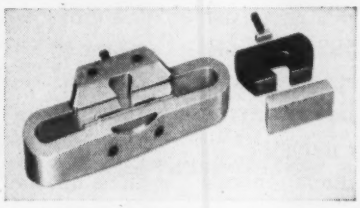


Figure 1

Now, however, magnet, mounting pin, and steel return path are assembled in a single operation – eliminating the difficult 3-stage fabrication job. This assembly – one of the most complex handled by the die-casting machine – illustrates the equipment's tremendous versatility.

Figure 2 is a generator rotor, consisting of eight G-E Alnico magnets held in position on a camshaft by the cast-aluminum matrix.

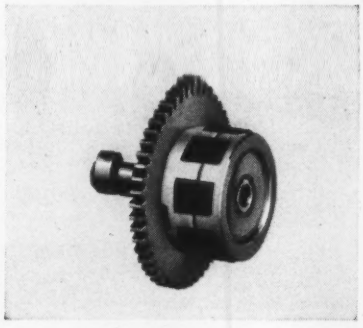


Figure 2

The casting supplements the strength of the magnets (which are subjected to high rotary speeds). And it eliminates difficult grinding, assembly, and banding operations.

The four radar magnetron tube magnets in Figure 3 give some idea of the wide range of sizes the machine is capable of handling. The smallest magnet (bottom, right) weighs only 1 lb., while a quarter section of the largest magnet weighs more than 11 lbs.

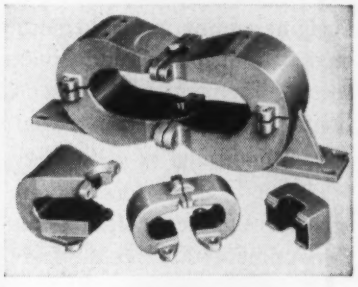


Figure 3

Here, the aluminum sheath improves magnetic stability by preventing direct contact between magnet surfaces and steel objects. In addition, the mounting brackets cast in the sheaths eliminate inserts normally cast in the magnets which would weaken its energy and structure.

Aluminum-sheathed magnets are often far less expensive than conventional magnets . . . especially on long production runs. And, in many of the cases where the unit cost of alclad magnets is higher, the tremendous advantages gained by die casting have more than offset the price difference.

The one best way to find out whether or not die casting is feasible on your application, is to check with a General Electric Magnet Engineer.

You can do this – or obtain information on any other problem in the realm of permanent magnets – by dropping a note to: *Carboloy Department of General Electric Company, 11126 E. 8 Mile Ave., Detroit 32, Michigan.*

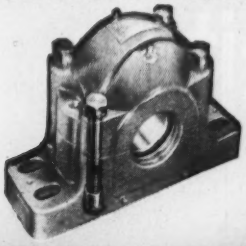
Progress Is Our Most Important Product

GENERAL ELECTRIC

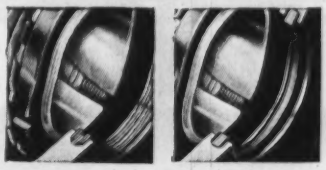
—ITEM 558—

MORE FACTS on why more and more leading manufacturers choose Link-Belt bearings

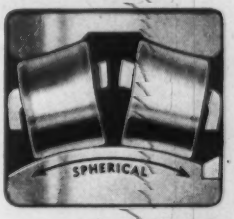
SUPER-RUGGED CAST STEEL HOUSING. Proper positioning of cap on base is assured by large-size dowels. Four heat-treated thru-bolts and serrated steel nuts firmly clamp cap and base together.

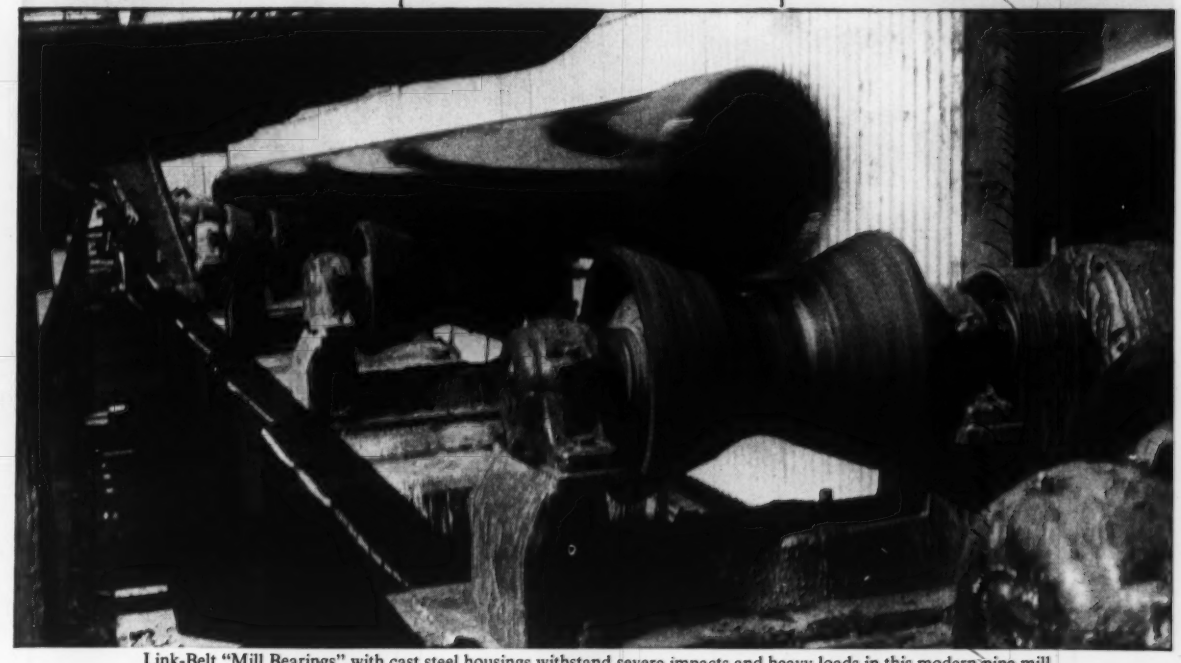


CHOICE OF SEALS. Spiral labyrinth steel seals, left, are for oil or grease lubrication and heat conditions. Combination felt and synthetic rubber contact-type seals, right, for grease lubrication.



SELF-ALIGNING ROLLER BEARING is self-contained and adjusted at the factory—needs no shims or alignment rings at installation. Design assures free rolling under even the toughest conditions.

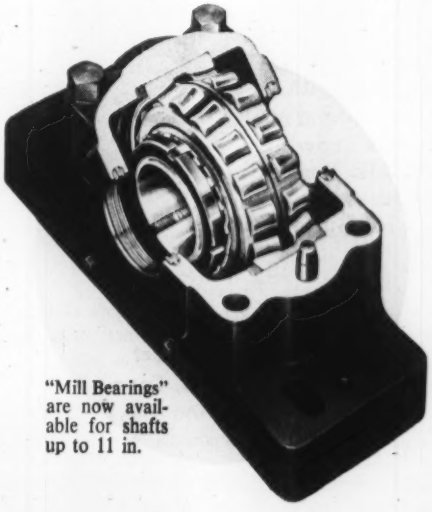




Link-Belt "Mill Bearings" with cast steel housings withstand severe impacts and heavy loads in this modern pipe mill.

"Mill Bearings" with cast steel housings

designed by Link-Belt to take industry's heaviest loads and hardest impacts



"Mill Bearings" are now available for shafts up to 11 in.

● To stand up to the sudden shocks and impact loads met in steel mills, mines, foundries, oil field applications and on heavy equipment, Link-Belt has designed the extra tough "Mill Bearing." It's the precision Link-Belt self-aligning roller bearing mounted and protected in a durable cast steel housing.

Thoroughly-proved Link-Belt "Mill Bearings" maintain full load capacity even with shaft deflections and misalignment often existing in extremely heavy service. And their simple, efficient design assures long life and free rolling.

Link-Belt makes industry's most complete line of ball and roller bearing blocks. So whatever you need, you'll find the answer in this quality line. Ask any of the 40 Link-Belt offices for Data Book 2550 and Book 2565A on "Mill Bearings."

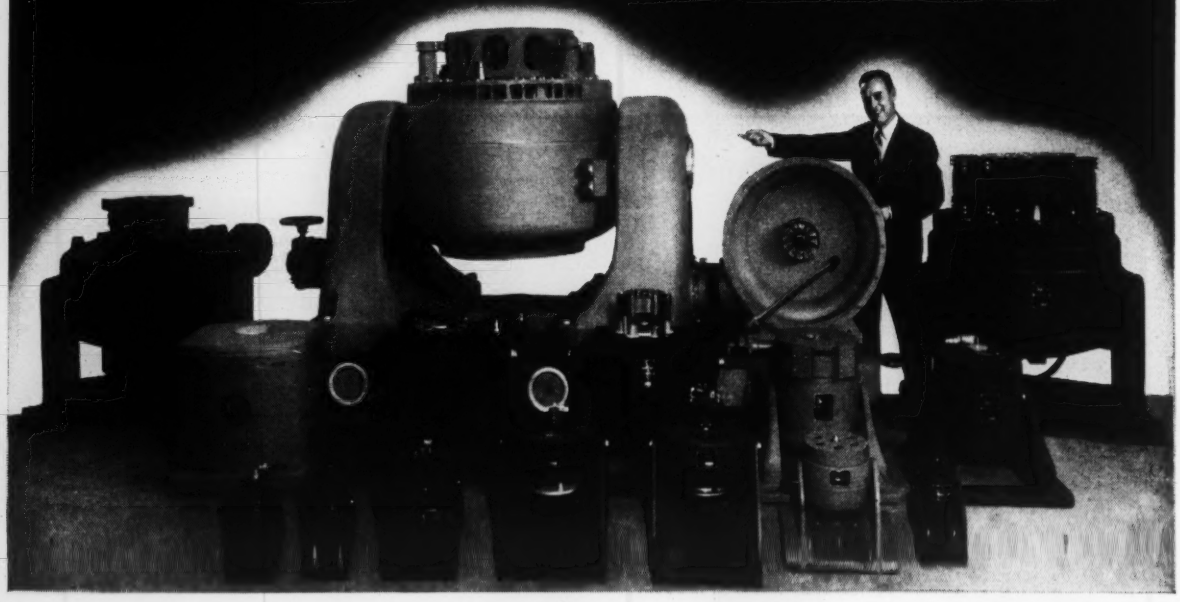
13,992-A

LINK-BELT

Ball and Roller Bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

Look at this progress in vibration exciters



A whole range of MB Shakers developed to handle any vibration testing program . . . deliver reliable, quantitative data

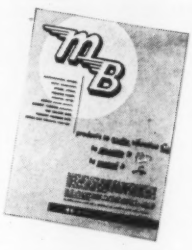
One pound to over twelve thousand pounds . . . that's the range of force outputs in this group of MB electrodynamic vibration exciters. On the way are shakers for 25,000, 50,000 and even 100,000 pounds! All operate over substantial frequency range. What a far cry from the limited scope of mechanical shakers . . . the only type available just a short ten years ago.

But force and frequency range are not the only improvements. MB has long recognized the need for *pure* table motion if test results were to be quantitative and reliable.

Thus, in MB Shakers, moving-element structures are very rigid. This minimizes table motion distortion in the testing range. Also, because MB power supplies are designed for negligible harmonic distortion, table waveform is pure over the whole frequency range.

There's more. MB has designed complex wave testing systems that shorten test time and give truer reproduction of actual service conditions. Also oil-filled exciters capable of operation at "100,000 ft. altitude," −100 to +200°F, and 20 to 95% relative humidities. Also cycling systems that do time-consuming test procedures *automatically*.

If you're working on projects that call for environmental testing, or fatigue testing, or noise determinations . . . you can benefit from vibration testing with MB shakers. Work with a leading source of help and information in this growing field . . . contact MB. For details and specifications on MB Exciters, send for Bulletin 420-5.



MB manufacturing company
A division of Textron American, Inc.
1060 State Street
New Haven 11, Conn.

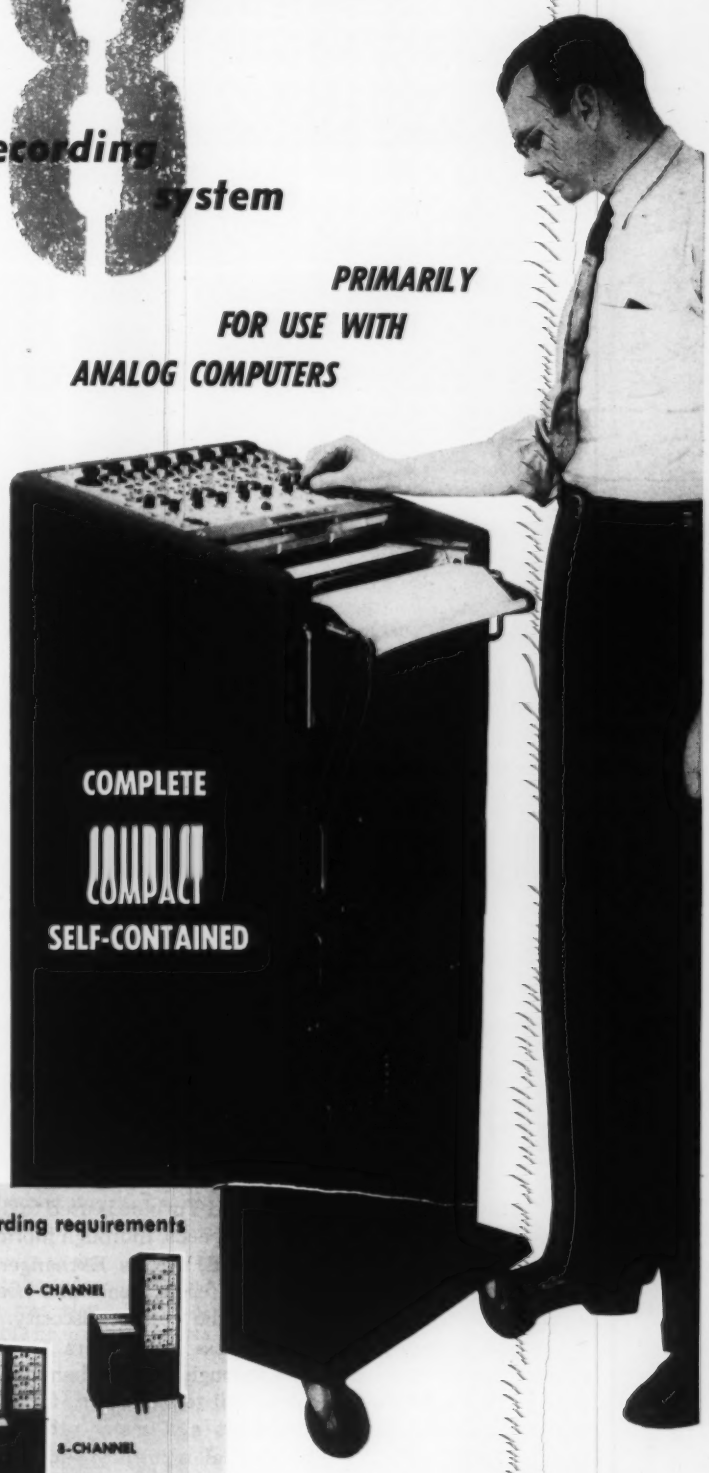
HEADQUARTERS FOR PRODUCTS TO ISOLATE VIBRATION . . . TO EXCITE IT . . . TO MEASURE IT.

—ITEM 560—
For More Information Circle Item Number on Yellow Card—page 19

NEW 8 CHANNEL

Sanborn oscillographic recording system

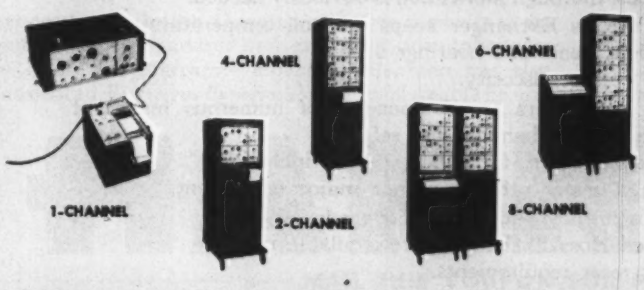
PRIMARILY FOR USE WITH ANALOG COMPUTERS



THIS new self-contained 8-channel oscillographic recording system, primarily for (but not limited to) analog computer recording, measures only 46½" x 27" x 22". In a single, space-saving mobile package, the user has a complete system for analog computer readout recording. Input cable connections are easily made at the top of the back panel. Eight groups of controls for the eight channels are conveniently located on the sloping top panel. Driver Amplifier chassis are easily withdrawn from the lower part of the console for inspection. Paper loading is quickly done from the top.

Features of the Model 158-5490 system include 0.1v/cm to 100v/cm sensitivity; over-all linearity of 0.25 mm over the entire 4 cm of the chart; drift less than 0.5 mm/hour; push-pull or single-ended input; miniaturized dual-channel DC amplifiers of improved current feedback design; 5 meg. input impedance each input lead to ground; true rectangular coordinate recording; nine chart speeds from 0.25 to 100 mm/sec. Frequency response is flat to 20 cps, down 2 db at 60 cps for all amplitudes to 4 cm peak to peak.

FAMOUS "150" SYSTEMS . . . for all recording requirements



In laboratories, production testing facilities and field installations nationwide Sanborn 150 Series Oscillographic Recording Systems are proving their versatility and value. Users have a choice of basic systems ranging from 1 to 8 channels . . . "packaged" as portable units or in vertical mobile cabinets . . . and twelve interchangeable plug-in preamplifiers permitting rapid, economical changeover to new input requirements.

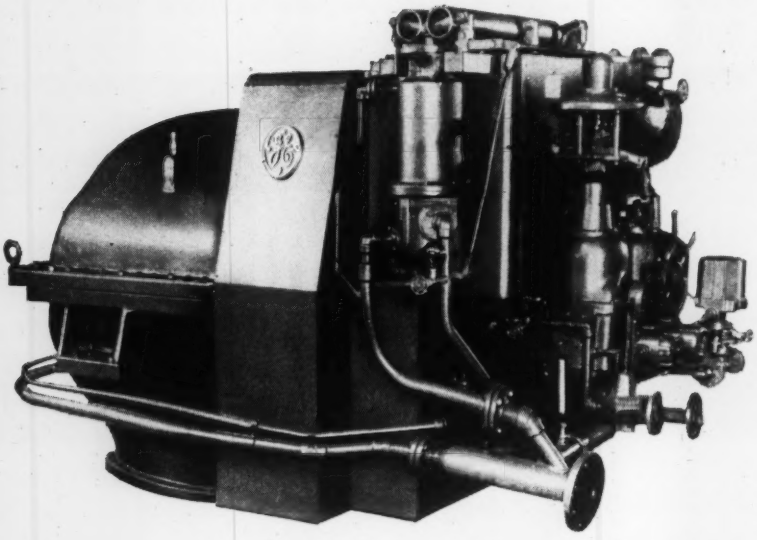
Sanborn will gladly furnish complete descriptive data on the new 158-5490 System and all "regular 150" systems, or engineering assistance on your recording problems, whenever you wish. Contact your Sanborn Representative, or write to . . .

SANBORN COMPANY

INDUSTRIAL DIVISION

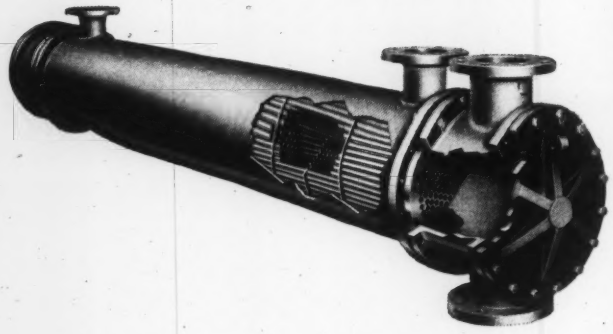
195 MASSACHUSETTS AVE., CAMBRIDGE 30, MASS.

—ITEM 561—



THIS TURBINE

+



ROSS

EXCHANGER

equal efficient, high-speed operation

This General Electric high-speed Turbine is used to drive modern compressors and blowers at 7000 rpm and up. At such speeds, thorough lubrication is obviously needed.

Factory-installed by G-E, a Ross Exchanger keeps lube oil temperature within recommended limits. As a result, gears and bearings always receive sufficient lubrication at the correct viscosity.

Rugged, dependable Ross Exchangers are components of numerous makes of turbines. In fact, they are used throughout the chemical and refining industries to control oil temperatures for engines, speed increasers, compressors, torque converters and many other types of major equipment.

Combining high thermal efficiency and extreme ruggedness, pre-engineered and fully standardized Ross Exchangers are available in a wide range of sizes to meet most requirements.

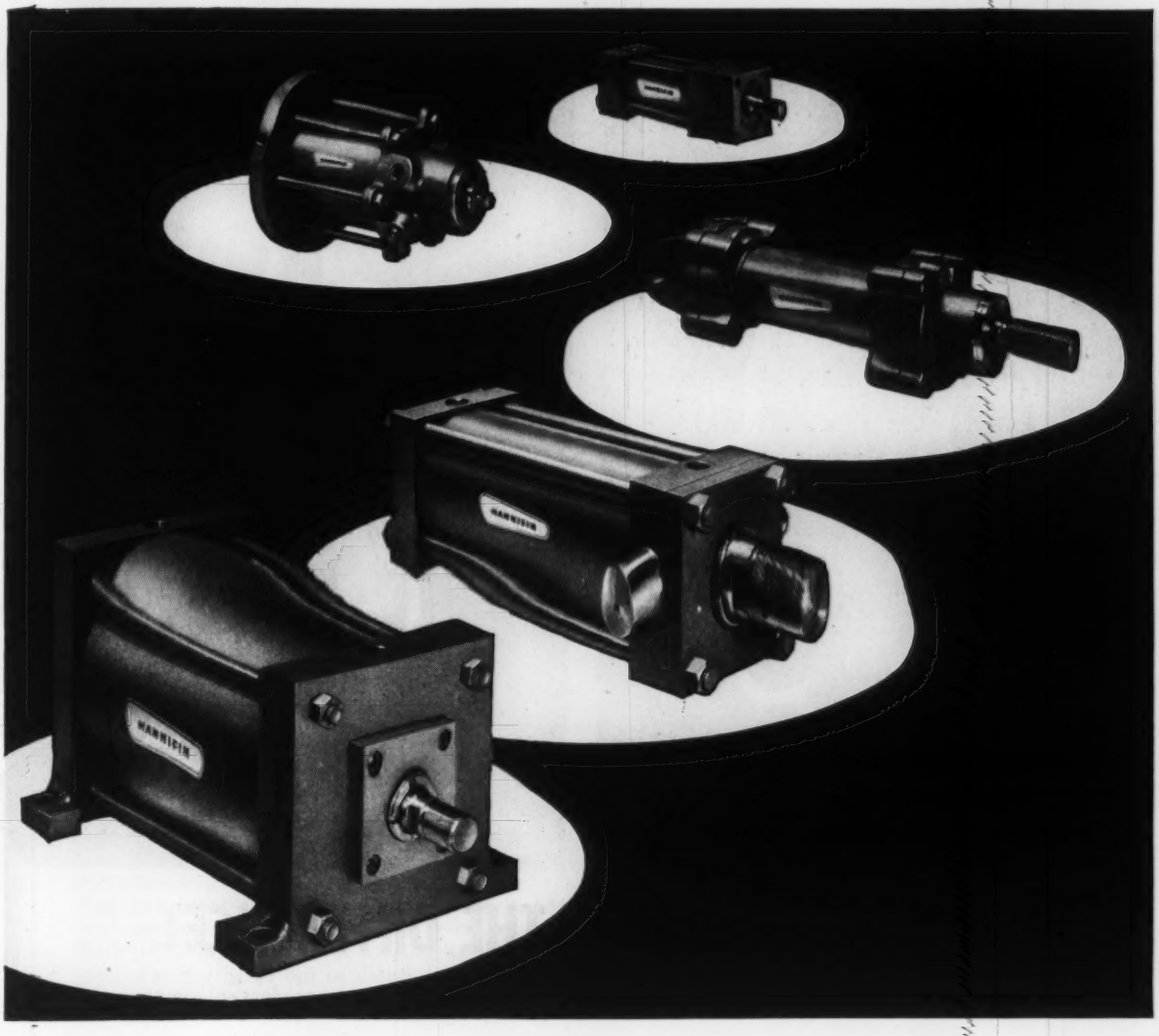
For complete detailed information, request Bulletins 1.1K5 and 2.1K5.

ROSS HEAT EXCHANGER PRODUCTS

ROSS HEAT EXCHANGER DIVISION
of
AMERICAN-Standard
1429 WEST AVENUE • BUFFALO 13, N. Y.
In Canada: Kewanee-Ross of Canada Limited, Toronto 5, Ont.

—ITEM 562—
For More Information Circle Item Number on Yellow Card—page 19

HANNIFIN AIR AND HYDRAULIC CYLINDERS



To the engineer who wants the best cylinder—in a hurry

In the selection and purchase of cylinders look for:

Completeness of Line. Hannifin makes *five* lines of air and hydraulic cylinders in a range of bore sizes and mounting styles to meet every requirement and preference.

Leadership in Design. Hannifin cylinders are built to exacting quality standards and extremely close tolerances to insure easy, accurate mounting. Hannifin has also introduced the *externally removable* and replaceable bronze gland cartridge, the most noteworthy improvement in cylinder design in the last 50 years.

Rapid Delivery. Hannifin can ship the cylinder you need in strokes up to 60" *in any normal quantity within 48 hours.*

Field Engineers, located in all principal cities, are as near as your telephone. Or, if your requirements are really urgent, call us at Des Plaines. Experienced sales engineers will handle your order.

HANNIFIN

MAIL THIS COUPON FOR PROMPT ACTION

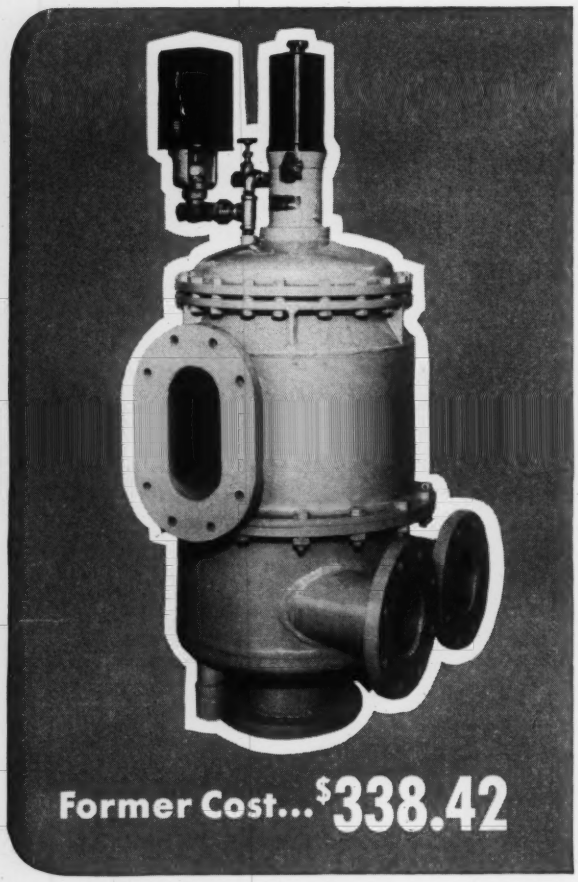
- ☐ Have Field Engineer call at once
- ☐ Have Field Engineer stop by soon
- ☐ For the present, just send complete catalog information on Hannifin cylinders including prices

Hannifin Corporation, 515 S. Wolf Rd., Des Plaines, Ill.

Name.....*Title*.....
Company.....
Address.....
City.....*Zone*.....*State*.....

—ITEM 563—

For More Information Circle Item Number on Yellow Card—page 19



GRAY IRON SAVES THE DIFFERENCE!

This manufacturer had an annoying valve service problem caused by leakage in fabricated assemblies. By converting to Gray Iron castings, he not only solved this service problem, but also effected a 70% saving in production cost.

Conversion to Gray Iron has also resulted in sharply increased sales of the valve, according to the manufacturer.

You, too, can improve product appearance and performance and enjoy cost reductions by switching to Gray Iron. Look at *your* products and see where this time-tested metal can transform present designs into better performing, lower cost units.

For specific technical or business information, write to Gray Iron Founders' Society, Inc., National City—East 6th Bldg., Cleveland 14, Ohio.

This symbol assures you the most for your casting dollar

Here's why it pays to call in one of the more than 500 leading foundries displaying the Society symbol:

- The most recent technical and business information is available to each member through the Society to help you design better products at lower cost.
- The use of sound cost accounting procedures is recommended and encouraged among Society member foundries, assuring full value for your casting dollar.
- Improved castings result from the advanced techniques and the high sense of responsibility of Society members.

MAKE IT BETTER WITH GRAY IRON

GRAY IRON FOUNDERS' SOCIETY

—ITEM 564—
For More Information Circle Item Number on Yellow Card—page 19
Facing Page—ITEM 565→

AJAX®

DIHEDRAL COUPLINGS

safeguard ALLIANCE CRANES *against misalignment*

Weaving, twisting, high torque, sudden starting and stopping and heavy loads are being handled on many Alliance Cranes by Ajax Dihedral Couplings.

This is another dramatic example of how the new and greater misalignment capacity of Ajax Dihedral Couplings overcome conditions that tear the heart out of direct-connected equipment. Ajax Dihedral Couplings protect motor housings and bearings, winches and running gear under the severe strains encountered on cranes, shovels, oil drilling rigs and other difficult jobs.

Ajax patented dihedral tooth design has less clearance than conventional gear type couplings. More tooth strength is provided under misalignment than is possible with any other tooth shape. Load is distributed at center of teeth at the point of greatest strength. Johns-Manville "Clipper" Seals keep lubricant in and foreign matter out.

Design engineers are invited to get the facts on Ajax Dihedral Couplings on this basis,—if you have alignment or misalignment troubles you can't afford to be without Ajax Dihedral Couplings! Tell us your troubles.

AJAX FLEXIBLE COUPLING CO. INC.

REPRESENTATIVES IN PRINCIPAL CITIES

WESTFIELD, N. Y.

Another PARKER Die Casting With...

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Produced complete in one operation . . . to extremely close tolerances . . . this helical gear part is yet another example of the way Parker-engineered die castings can save you money by eliminating costly tooling-up and machining operations on component parts. Combine this inherent cost advantage with exceptionally smooth as-cast finish, high density and good tensiles and you can see why Parker Die Castings—in zinc or aluminum—open up wide new possibilities to the design engineer.

Parker has been a leader in die-casting for 50 years—an old hand with new ideas. Take advantage of this skill. Just call the nearest Parker sales engineer or write the factory direct.

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high pressure ALUMINUM and ZINC die castings

POWDERED METAL PARTS

DU PONT
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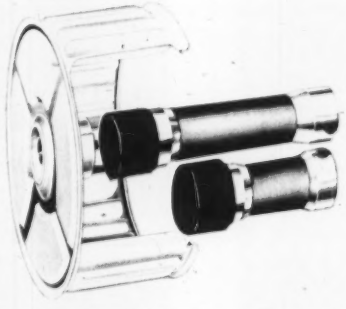
PROPERTY AND APPLICATION DATA
ON THESE VERSATILE ENGINEERING MATERIALS
"ZYTEL," "ALATHON," "TEFLON," "LUCITE."

NEWS

Tough, flexible hose of Du Pont TEFLON® withstands temperatures up to 450°F... is inert to corrosive fluids

Splined sleeve for new flexible coupling molded of tough ZYTEL® nylon resin

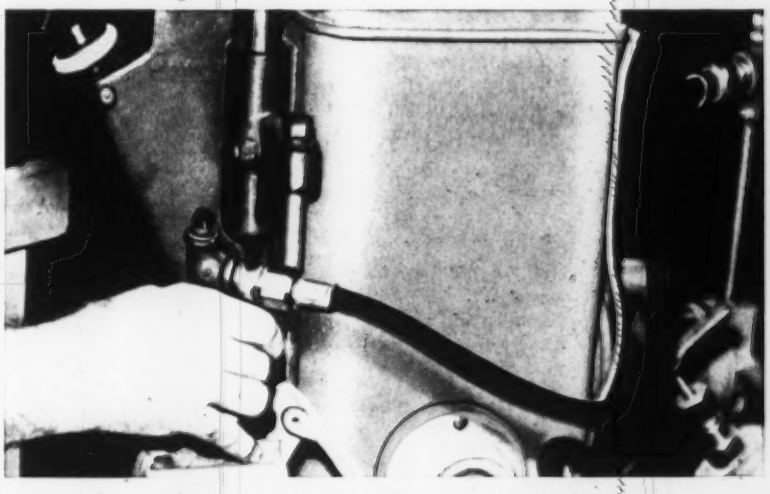
Now, molded ZYTEL nylon resin, with its outstanding wear resistance, toughness, strength in thin sections and freedom from need of lubrication, brings improved performance to this oil burner drive. A splined sleeve of ZYTEL offers continuous high-slip, lateral motion, and low-friction surface which will not gall on the blower wheel hub.



Blower wheel to which flexible couplings attach in gun-type oil burners. Also pictured are two coupling sizes with new splined sleeve of ZYTEL indicated in red. (Manufactured by Guardian Products Corporation, Coupling Division, Michigan City, Indiana.)

Du Pont ZYTEL replaces the aluminum drawn tubing which was previously standard in this application. The ability of ZYTEL to be molded to close tolerances enables the sleeve to offer tight, minimum-diameter clearances. Also, ZYTEL is impervious to fuel oils and stable at elevated temperatures. It offers silent, smooth operation for many years of trouble-free service.

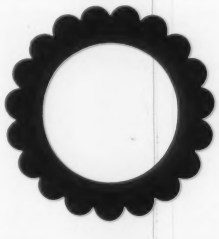
From the initial molding process to the installation of the coupling, ZYTEL offers cost savings to both manufacturer and users. ZYTEL is easily and inexpensively injection molded and requires no further finishing. Installation and downtime are considerably reduced. Perhaps your product could be improved with a proper application of Du Pont ZYTEL. For further property data and application information, clip and mail the coupon on the other side of this page.



After three years' use, this hose lined with Du Pont TEFLON is unaffected by the adhesives it handles, despite constant flexing. (Manufactured by Resistoflex Corporation, Roseland, New Jersey.)

INDUSTRIAL hose lined with TEFLON tetrafluoroethylene resin offers longer service life and an increased range in applications involving extreme temperatures and pressures. TEFLON replaces natural or synthetic rubber linings and is the answer to the problem of conveying adhesives or corrosives.

The Compo Shoe Machinery Corporation, Boston, Massachusetts, is a leading producer of shoe machines and adhesives. In their machines for cementing shoe soles and bottoms, they employ a flexible hose to transmit adhesives from the storage pot to the nozzle. They formerly used hose lined with synthetic rubber. It lasted no longer than a year. They then switched to hose of TEFLON, and users report that the hose is virtually "as good as new"... even after three years' use.



Cross section of Resistoflex hose lined with TEFLON and jacketed with stainless steel wire braid. Hose is reported to have practically unlimited shelf and service life.

The list of applications for hose of TEFLON is ever-increasing. Hose made of TEFLON is now standard equipment for hydraulic and fuel lines in jet aircraft, where the flow of corrosive synthetic fuels at high temperatures demands hose material that is rugged and flexible. It is used to convey steam (at 340 F.) under pressures of 170 psi, in a plastic molding application where it is subject to constant flexing.

TEFLON is inert to all chemicals except alkali metals and fluorine under special conditions. Its working temperature range extends from −450 F. to 500 F. It is strong, flexible and nonflammable. The smooth, wax-like surface of TEFLON prevents even the strongest adhesives from sticking to it.

A proper application of TEFLON can provide cost savings as a result of longer service life, reduced downtime or maintenance time. Its unique physical, electrical and chemical properties make TEFLON adaptable to a wide range of applications. Can you take advantage of the remarkable properties TEFLON has to offer? For a comprehensive report on its properties and proven applications, mail the coupon on the other side of this page.

OVER

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Better Things for Better Living ... through Chemistry

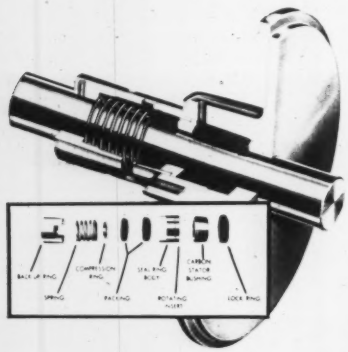
PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA
ON THESE VERSATILE ENGINEERING MATERIALS
"ZYTEL," "ALATHON," "TEFLON," "LUCITE."

TEFLON® simplifies design and reduces costs in mechanical seals

LATEST design in mechanical seals features complete and rapid interchangeability with packing. Developed by Chemical and Power Products, Inc., New York City, this new seal can be made to fit any stuffing box, requiring no alterations or special clamps. It offers economy by eliminating product loss and minimizing installation and downtime.

TEFLON tetrafluoroethylene resin plays the feature role in the sealing of corrosive liquids and slurries. TEFLON is used as a shaft packing in the form of a male and female cup, providing maximum flexibility with minimum spring pressure as a wedgelock in the bottom of the seal to prevent leakage and stop rotation of the stator. The self-aligning wedgelock of TEFLON slips easily in place, and the time and expense involved in installing a clamp to hold the stator are eliminated.



TEFLON is selected in many sealing applications because of its superior physical and chemical properties. TEFLON is chemically inert, and will operate within extreme service temperatures ranging from −450° F. to 500° F. It is nonflammable, has zero water absorption, has low-temperature toughness and a low coefficient of friction.

A proper application of TEFLON can help you solve design problems involving extreme heat or corrosion.

New valve housing economically molded of Du Pont ZYTEL® nylon resin

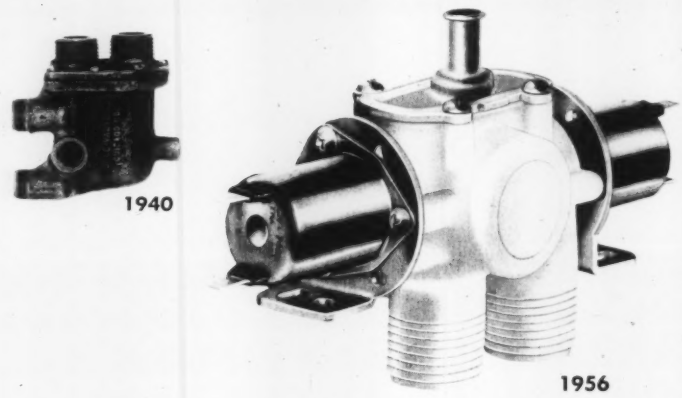
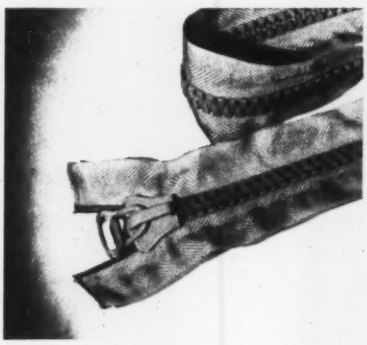


Illustration shows design change in thermostatically operated water control unit in past sixteen years. A housing of ZYTEL has replaced brass in this modern automatic home washing machine valve. (Housing molded by Chicago Molded Products Corp., Chicago 57, for The Dole Valve Co., Chicago 12, Illinois.)

THE unique properties of ZYTEL nylon resin make it particularly adaptable to this new valve body design. ZYTEL is easily injection molded to close tolerances. ZYTEL is tough, abrasion resistant, strong in thin sections, light in weight and offers good chemical resistance. It provides quiet operation with little or no lubrication, and possesses good insulating characteristics.

The molded threads on the two inlets in the thermostatically operated water control unit pictured above provide a strong, leak-proof connection when used with a standard hose coupling. The resistance of ZYTEL to water and chemicals prevents corrosion. In hard-water areas, these valve bodies are unaffected by deteriorating action of minerals present.

Slide fasteners of ZYTEL have been designed for use in a wide variety of military and consumer goods. Fasteners operate smoothly, even in extremes of temperatures . . . are resistant to mildew, corrosion and chemicals. They can be molded in a broad range of colors. (Manufactured by Waldes Kohinoor, Inc., Long Island City 1, N. Y.)



Investigate DuPont engineering materials in your product development programs

One of the family of these versatile engineering materials is often a key factor in product improvement or new product design. The wide range of properties available with ALATHON® polyethylene resin, LUCITE® acrylic resin, TEFLON® tetrafluoroethylene resin, and ZYTEL® nylon resin are helping solve industrial design problems.

NEED MORE INFORMATION? Clip the coupon for additional data on the properties and application of these materials.

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Room 126, Du Pont Building, Wilmington 98, Delaware.
In Canada: Du Pont Company of Canada, Ltd., P. O. Box 660, Montreal, Quebec.

Please send me more information on the Du Pont engineering materials checked: ☐ *ZYTEL;* ☐ *ALATHON;* ☐ *TEFLON;* ☐ *LUCITE. I am interested in evaluating these materials for:*

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A unique springmaking service . . .

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For Ball Bearings

THE TREND IS TO SKF®

Sleek, slim, powerful, quiet... *Mercury Outboards* are the ruler of speed and spray – "Master of the Waterways." Kiekhaefer Corporation, who makes them, was first to feature extensive use of anti-friction bearings in outboards. And Kiekhaefer is another concern that purchases single row, deep groove ball bearings from SKF.

It's a trend... brought about because those whose business is to buy bearings recognize the improvements SKF has achieved in ball bearings – improvements in quiet running, improvements in sealing, improvements in bearing life. Maybe *you* too should switch to SKF Ball Bearings.

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

SKF

has them all

Ball Bearings ◯ Cylindrical Roller Bearings ▭

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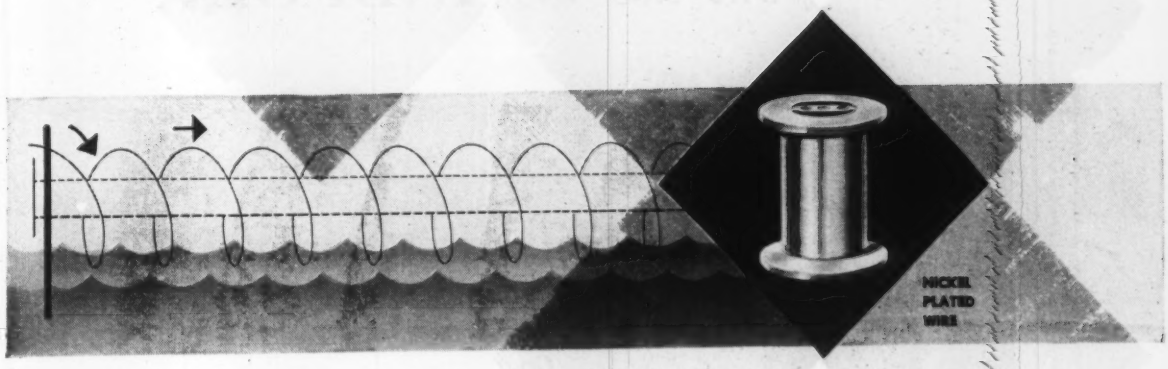
Nickel plated copper is just one of the many special wire composites developed by Sylvania to meet exacting wire requirements.

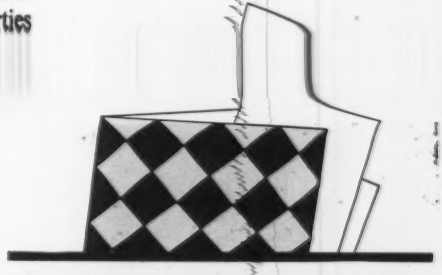


Sylvania **composite wire** offers high conductivity at higher operating temperatures

DO YOU HAVE AN APPLICATION for a high conducting wire that can withstand higher temperatures? If so, Sylvania's nickel plated wire can offer the right solution, at the right price.

Here is a wire which has conductivity approximating that of copper, yet will withstand operating temperatures up to 150° C higher than copper.

Nickel plated copper is just one of many special cold-drawn wires developed by Sylvania. If your interests include other than magnet wire types, it will help you to know that Sylvania is one of the nation's top custom platers of wire. Depending on the properties you want, Sylvania can custom plate wire in ranges from "flash" to 20% by weight in a wide range of materials and supply it in sizes from .250 to .002. Your custom wire can be clad, too, in just about any combination of materials.



Special Wire is an important phase of Sylvania's unique service to product designers. For the complete story write for the Wire Facilities brochure. It's included in Sylvania's "Portfolio of 4-way service to designers." Address Dept. F52S.

PARTS DIVISION

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—ITEM 570—
For More Information Circle Item Number on Yellow Card—page 19

(Advertisement)

the characteristics of ARMASTEEL® *from the* STANDPOINT OF

by

HAROLD G. SIEGGREEN

Chief Engineer
Central Foundry Division
General Motors Corp.

One of the many problems which today confront the engine designer emanates from the restricted space in the crankcase. Here is what I mean . . .

Automotive sales departments are perennially pressing the engine designers for better performance to keep up with competition. By applying the results of research, the design engineers have been able to partially satisfy the demand by increases in compression ratio, freer breathing and improved carburetion. This is accomplished, of course, by larger valves, high lift cams, and by multiple carburetors.

Because there is a limit as to how much the maximum horsepower can be increased by changes in breathing, and because of the real need for higher torque, the designer must sooner or later think in terms of larger pistons and/or greater length of stroke. This, in turn, means greater rotating and reciprocating forces which in the new and modern V-8 engine must be balanced by larger counterweights. And up until recently, this presented a serious problem due to the usual restricted area of the crankcase. But now, the problem is solved with relative ease . . . for the shell-molding process allows considerably greater latitude in the design of the counterweights.

With shell casting, it is now possible to flare the counterweights to any desired width (end surfaces can be practically perpendicular to pattern parting) to achieve the maximum balancing effect. Radii of counterweight tips can be consistently cast as low as ⅛" (in other methods of producing crankshafts, the variation on the tips or corners was so great that a 1" radius was usually specified). Shell-cast crankshafts are produced with extremely narrow spaces between the counterweights. In fact, the drawing of deep and narrow pockets of this nature is entirely practical now. (These points are illustrated in my two accompanying sketches).

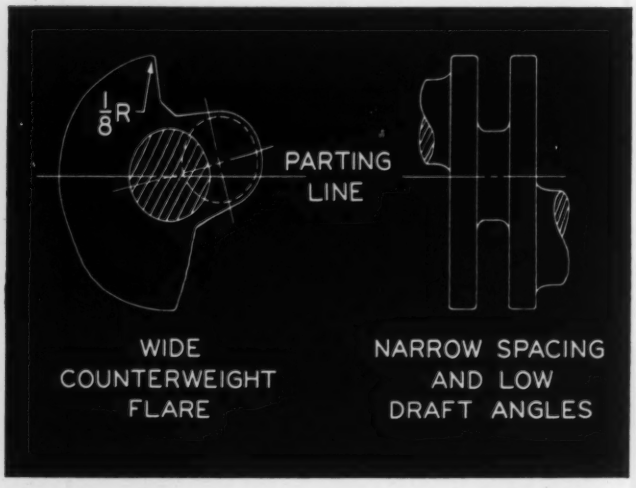
Another example: draft angles of less than ½ degree are commonly used. All these factors make it feasible to produce the eight counterweight shafts for V-8 engines which many engineers favor because of their ability to decrease crankshaft deflection and loads on main bearings. With shell-cast ArmaSteel, crankshafts can now be made for even the extremely difficult V-6 engine. (See photographs.)

Also from the standpoint of machining, the new shell-cast ArmaSteel crankshafts present substantial advantages. It is now possible to eliminate the cheeking and turning operations on the sides and on the outside diameters of the counterweights on some designs. When these machining operations are necessary to attain maximum counterweight thickness and diameter only a minimum of stock need be removed.

The good dimensional control of shell-cast crankshafts, over long production runs, provides for consistent balance drilling. This dimensional control is due to the negligible pattern wear, and the hard, smooth, and accurate mold. (Shell-molds are bonded by phenolic resin and cured before stripping from the pattern.)

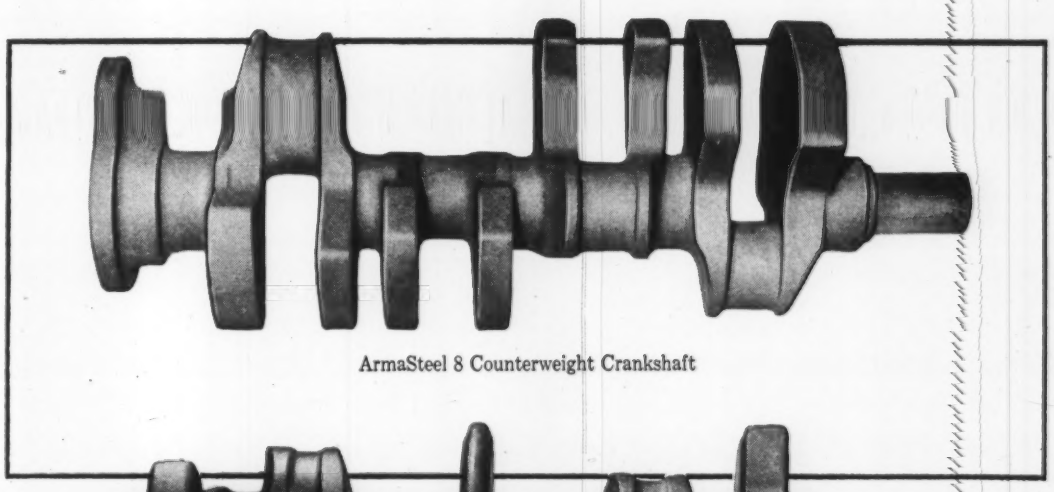
By using accurately machined patterns, with the crankpins positioned, the completed castings provide excellent crankpin index.

It is the combination of the method, shell-casting, and the material, ArmaSteel, that makes the cast crankshafts so practical. The metal, ArmaSteel, combines the advantages of both castings and forgings. It possesses unusual resistance to fatigue and wear. Its rigidity (modulus 26 to 28 million) results in minimum deflection —therefore accurate alignment. Its high damping capacity allows it to absorb vibrant energy and thus contribute to noiseless operation.

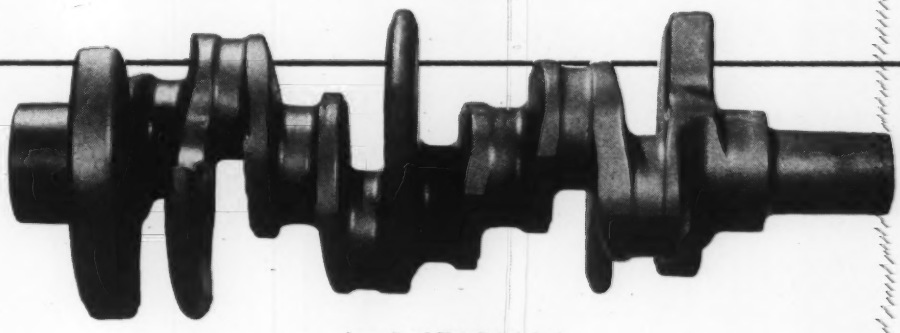


SHELL-CAST CRANKSHAFTS

DESIGN



ArmaSteel 8 Counterweight Crankshaft



ArmaSteel V-6 Crankshaft

Unlike many cast materials, ArmaSteel is ductile and therefore does not break under ordinary handling, machining, or impact loads. Its high tensile strength (90,000 psi for the crankshaft grade) renders ArmaSteel highly desirable not only for crankshafts, but for many other highly stressed components.

ArmaSteel crankshafts are inspected in a great many ways here at Central Foundry Division—both conventional and unique. 100% hardness testing, magnetic particle inspection, and sonic testing (a Central Foundry development) are given each crankshaft. In addition, gamma-ray radiography is used as another control measure. Indication of performance is proven by 3½ years of thorough testing in various types and sizes of passenger car and truck engines. (In extremely critical laboratory and road tests, the ArmaSteel crankshaft remained intact while other engine parts failed.)

The lower specific gravity of ArmaSteel (.2665 lbs. per cu. in.) means a lighter crankshaft. (4 pounds lighter in the case of one popular V-8 engine.)

In my opinion, the biggest reasons for the automotive industry to switch to the shell-cast ArmaSteel crankshaft are the lower net cost plus a greatly improved product. Savings result from: less material purchased; lower freight (because of the casting being so much closer to final dimensions) and considerably less time, labor, tool-wear, etc. in the entire machining and finishing cycle.

All in all, I believe, shell-cast ArmaSteel promises much for the design engineer, the production engineer, the cost engineer and the ever-demanding sales department.

For information on how your product can also benefit from ArmaSteel, the metal, and Shell Molding, the process, write today for your copy of the "ArmaSteel" catalog and the pamphlet "Shell Molding at Central Foundry."

70

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

—ITEM 571—

For More Information Circle Item Number on Yellow Card—page 19

Concentrated Heat for Industry*

Scientists and engineers have done a tremendous amount of work, over the past 10 years, with new techniques in burning fuels. Most of their work has been aimed at the goal of making airplanes and rockets fly faster. Now, as this illustration shows, industry is picking up some of the techniques for its own use.

and smaller area can pay off in the operations of several industries. But a[illegible] it stands, a jet turbine's [illegible] too rich for a pl[illegible] bine's f[illegible]

...built around

Carpenter Stainless Tubing

for Long Life!

This unique type compact heat exchanger has found ready acceptance as a highly efficient and dependable source of hot air or gas at pressures up to 300 psi and temperatures to 1200°F. Carpenter Stainless Tubing met every requirement of the manufacturer—superior strength at high pressures and temperatures, easy fabrication, uniform expansion, oxidation resistance and long, maintenance-free performance. That's why Carpenter Stainless Tubing is used exclusively for the straight tube and coiled fin-tube bundles, both shown at right partially assembled.

Any heat transfer equipment worth building or using is worth Carpenter quality. It costs no more . . . because all full-finished Carpenter Stainless Tubing meets the high and uniform quality requirements for heat exchanger applications. And you are sure of getting the highest possible degree of perfection in Carpenter tubing because it must pass the most exacting and thorough non-destructive test ever applied to stainless tubing.

Call your nearest Carpenter Distributor or Branch Office to give your equipment the benefit of better-than-ever Carpenter Stainless Tubing.

MEMBER

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

Carpenter

more than corrosion resistance

Stainless Tubing & Pipe

*from BUSINESS WEEK of January 22, 1955

CLARE

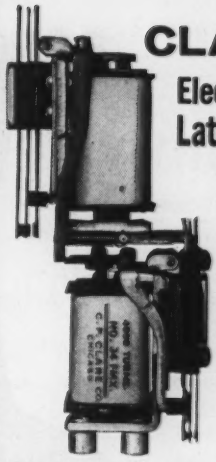
Spring-driven Stepping Switch

(TYPE 11)

Latest in CLARE line of uniselectors, or rotary switches for completing, interrupting or changing connections in a succession of electric circuits in response to momentary impulses of current. Provides millions of steps without readjustment. *Send for CLARE Bulletin No. 121.*

CLARE

Electromechanical Latching Relays



Assembly consists of two CLARE a-c or d-c relays with interlocking armatures. One a-c and one d-c relay may also be used. Many of these relays still operating satisfactorily after well over 15,000,000 operations. *Send for CLARE Bulletin No. 118.*

New CLARE RELAY designs keep pace with demands of modern high-speed equipment

CLARE RELAYS for use in modern high-speed devices differ in size, shape, appearance and characteristics to meet a wide range of design requirements.

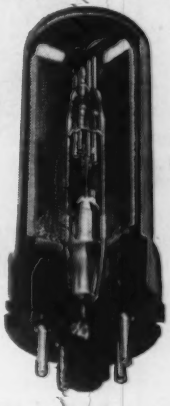
One factor they have in common—ability to deliver accurate and dependable performance for millions, yes even billions, of operations WITH NO MAINTENANCE WHATSOEVER.

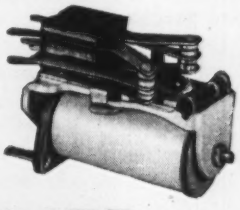
A few of these outstanding CLARE developments are shown. There are many more. If your relay problem is new or unusual, CLARE sales engineers, located in key cities, may be able to bring you quickly just the relay you need. Contact C. P. CLARE & CO., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. CLARE & CO., 659 Bayview Avenue, Toronto 17. Telephone: Mohawk 3829.
Cable address: CLARELAY.

CLARE

Mercury-Wetted Contact Relays

A relay of the utmost accuracy and dependability which is capable of over a billion operations at speeds to 60 operations per second. Cutaway view shows mercury-wetted contact switch sealed in glass. Available with up to 4 switches for multiple circuits. *Send for CLARE Bulletins Nos. 120 and 122.*





CLARE

Type J Heavy-duty Contact Relay

Increased current carrying capacity is provided by the use of silver heavy-duty contacts which are riveted to the springs.

Rating of 10 amperes, 27½ volts d-c. Has exceeded 500,000 operations on motor load of six amperes—inrush current of 15 amperes—at 70,000 feet altitude. *Send for CLARE Bulletin No. 119.*

CLARE

High Frequency Impulse Relay

A highly sensitive relay completely free from contact bounce and capable of billions of operations at extremely high speed. (Will follow up to 2,500 CPS.) *Send for CLARE Bulletin No. 117.*

CLARE RELAYS

FIRST in the industrial field

Illustrating the effective use of die castings in a complete set of Electric Saw Castings made in close cooperation with the Engineers and Designers at Signal Electric Division of King-Seeley Corporation.

mass marketing wisdom

with MADISON-KIPP zinc and aluminum die castings

A PRODUCT having instant and striking eye appeal sells more readily than one with a clumsy looking design. It sells better but probably not on "looks" alone. The buyer, consciously or unconsciously, may quickly conclude that good looks are combined with more thoughtful engineering—and he is right in such an evaluation.

To upgrade your product you may find that the skilled and seasoned mechanics at Madison-Kipp can be very helpful. Many highly placed engineers and designers have found this to be true for over a quarter of a century.

Please clip this ad as a reminder to contact us when you have die casting requirements.

kipp

MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WIS., U. S. A.

Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

—ITEM 574—
For More Information Circle Item Number on Yellow Card—page 19

Design data on adhesives

(Advertisement)

Armstrong
ADHESIVES • COATINGS • SEALERS

NUMBER THREE

Strengthening a metal-to-metal joint

Four basic rules must be kept in mind in order to strengthen any joints to be adhesive-bonded.

These rules are:

1. Make the bonded area as large as possible.
2. Make the maximum proportion of bonded area contribute to strength.
3. Stress the adhesive in the direction of its maximum strength.
4. Minimize stress in the direction in which adhesive is weakest.

Here's how two of these rules were applied in improving the bond of a metal label to a fire extinguisher.

A

This label was designed for fastening with rivets. The label is flat, has embossed letters, and has holes drilled for riveting. Contact is very poor because of the embossing, resulting in low strength and low resistance to peel or cleavage stresses on the edge of the joint.

B

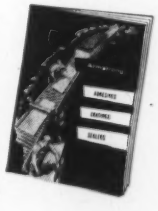
Remedy

This label was designed for adhesive bonding. The label is pre-curved and has a smooth back for 100% contact. This type of bond will prevent failure when a stress is applied at the edge of the bond with a fingernail or, for example, with some sharp instrument.

1. Bonded area has been made as large as possible.
2. Maximum proportion of bonded area now contributes to strength.

For more information

Write for a copy of "Armstrong Adhesives, Coatings, and Sealers." Armstrong Cork Company, 8006 Dean St., Lancaster, Penna.



Factors in adhesive bonding

Most assembly requirements for adhesive-bonded materials include factors of time, heat, and pressure. These vary with the adhesive used and also with the materials bonded.

Time

Two time factors are involved, open time and setting time. Open time is the period of time that can or must elapse between coating the parts and joining them. Some adhesives permit little open time; others must be kept open for intervals ranging from five minutes to twenty-four hours.

Setting time is the period that must elapse before an adhesive bond attains its full strength. Here again the interval may be measured in seconds or weeks, depending upon the adhesive, the materials bonded, and the curing procedure, if any.

Heat

Heat is required in varying degrees in many adhesive applications. Whether one or both surfaces are coated, forced drying of the adhesive film by heating and circulating air is usually desirable and often necessary. The use of heat speeds drying, makes drying independent of weather conditions, and prevents water condensation on the adhesive film.

PHOTO COURTESY CHEVROLET-DETROIT GEAR AND AXLE DIV., GENERAL MOTORS CORP.

ADHESIVE-COATED brake shoes and brake bands are assembled on a conveyor line. The brake band is first placed inside a pressure band and against the brake shoe. Pressure springs are then positioned. The assembly is then baked.

Controlled drying also makes it easier to begin assembly when the adhesive film has the right amount of tack, this being the point at which the best over-all bond can be made. Under some conditions, it may be more practical to dry the adhesive film completely and later reactivate it with heat or a solvent.

Special Factors

Thermosetting adhesives, which set by a chemical change in the presence of heat and/or a curing agent, require special assembly techniques. Adhesives of this type are most always used in critical applications where the possibility of bond failure cannot be tolerated—as in the bonding of clutch facings to steel plates. Since such bonds cannot be tested except by destruction, they must be made with extra care and control.

Curing

Some thermosetting adhesives must be cured by chemical reaction at room temperature, the bonded parts remaining clamped for a relatively long period of time. Oven heating of assemblies is quite common. Ovens may be heated by gas, oil, electric, or by infrared units. Forced circulation is required by oven heating in order to insure uniform temperature. The fastest curing time is accomplished by dielectric heat, which cures some heat-set adhesives in a few seconds.

Thermosetting adhesives may be cured at temperatures from 75° to 550° F., depending on the specific type. In general, the higher the temperature, the faster the cure. By controlling temperature, the bonding operation can be speeded or slowed to match the pace of almost any assembly line. Parts bonded with thermosetting adhesives usually can be taken from the presses while still hot.

For detailed information on bonding thermosetting adhesives, see the Armstrong Data Sheet, "Thermosetting Adhesives." It is available upon request. Write for your copy today.

Nickel plated inside and out to meet rigid specifications of Atomic Energy Commission, these pressure vessels comprise one of many trainloads fabricated by Newport News Shipbuilding and Dry Dock Company, Newport News, Virginia.

Designers specify nickel plated vessels to guard product purity

Designers, along with plant operators in scores of industries, find that a reasonable thickness of nickel plating helps in three ways:

First, by guarding equipment against mild corrosive attack.

Secondly, by protecting product purity during the production cycles.

And last but not least, by providing such protection economically.

Operators of food, chemical, petroleum and other process plants have made significant savings by use of nickel plated equipment.

Economical protection

Heretofore, electroplating of large complex shapes posed several difficulties. But thanks to expansion and improvement of facilities, nickel plating is no longer limited to relatively small, simple forms.

Even on the most intricate shapes of low-cost base metals, new techniques now permit plating a uniform, extremely hard, corrosion-resisting coating of nickel that offers sturdy protection.

Dependability of advanced methods has made it practicable to nickel-plate large quantities of equipment to meet exacting demands of the Atomic Energy Commission. Likewise to meet needs of commercial installations.

Consider how you, too, can save money by use of nickel plating to resist corrosion or to protect product purity. And at the same time cut initial cost of the equipment. Plating with Inco nickel has solved numerous problems. It may be the answer you seek. So send us the details of your metal difficulty. We'll be glad to give you suggestions based on our long practical experience. Write us today.

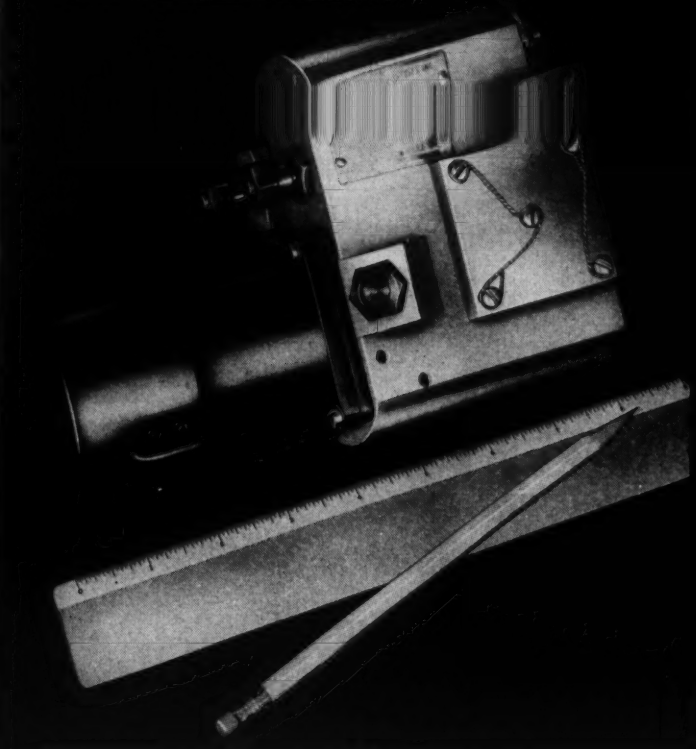
INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

For More Information Circle Item Number on Yellow Card—page 19

Facing Page—ITEM 576→

AIRCRAFT-TYPE hydraulic POWER UNITS . . .



To supply dependable hydraulic power for critical applications, Eastern units are engineered to perform under extreme conditions. Compact design and varying motor sizes make them unique power sources, especially desirable for airborne use. The equipment illustrated in detail presents a typical Eastern Power Unit designed for one application. Many other requirements can be satisfied with designs of this general type.

Unit consists of: positive-displacement pump, electric motor drive, oil reservoir, expansion chamber, porous bronze ten-micron filter, pressure regulating valve, filter relief valve, and expansion relief valve.

SPECIAL UNITS to be built into Servo Systems and specialized projects are available. As illustrated below, Actuators combined Servo-valve and Actuator, and Servo-valve Hydraulic System combinations are being produced by Eastern for custom-specified jobs. If your project involves equipment of this type, write to us for further information.

Specifications:

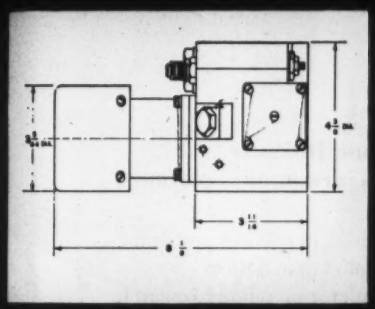
Available with either 1/8, 1/4, or 1/2 horsepower motor, in 28 V. D.C. or 400 Cycles 3 Phase power.

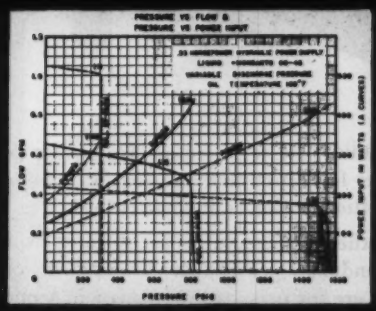
Available with various pump characteristics.

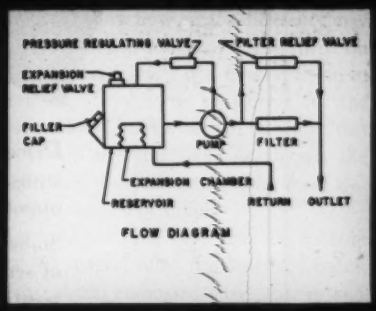
Under certain operating conditions, units can be made self-cooling. *Example:* 1/4 H.P. Unit has a continuous-duty oil-temperature rise above ambient of approximately 60 F. at sea level.

Pressure range from 0 to 1500 PSIG with compatible flow.

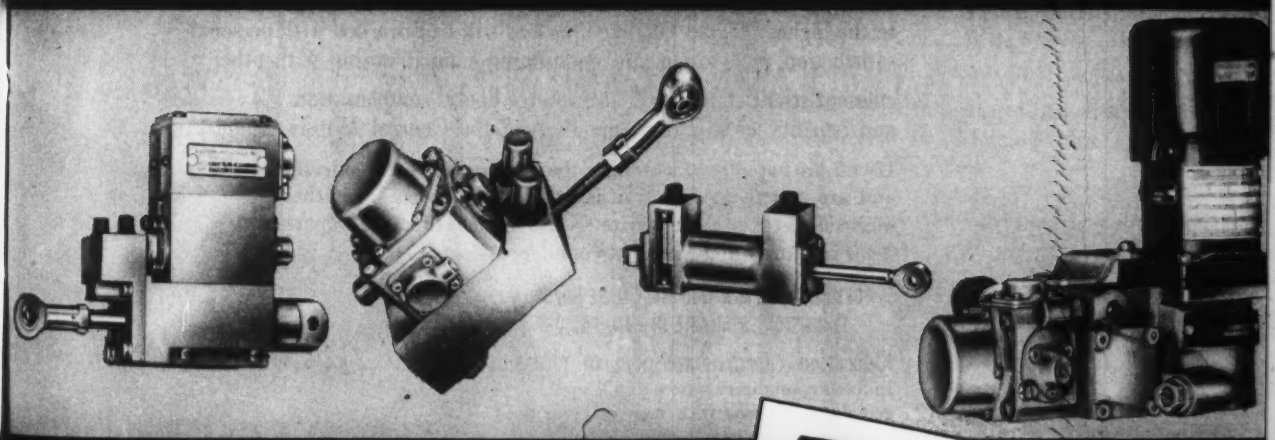
Anodized aluminum body contains all components except motor.





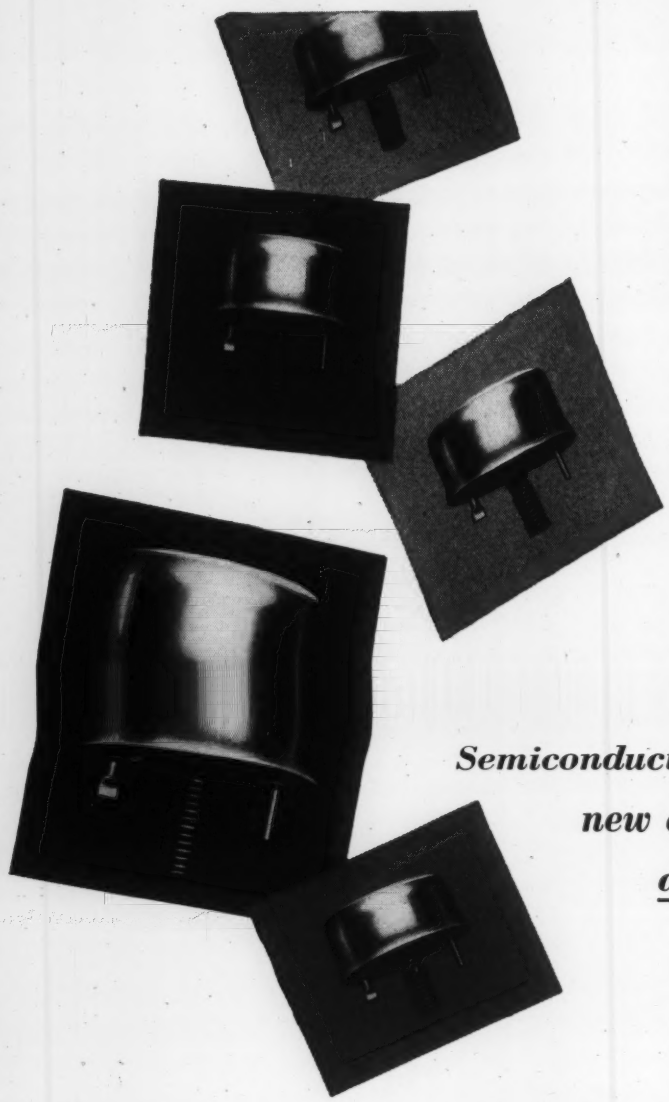


FLOW DIAGRAM



Write for Aviation Products Catalog 340

Eastern INDUSTRIES, INC.
100 SKIFF STREET
HAMDEN 14, CONN.



Semiconductor engineers find new opportunities at Delco Radio!

Delco Radio, first organization to develop and use Hi-Power transistors for automotive application, now offers permanent employment opportunities to men of highest caliber.

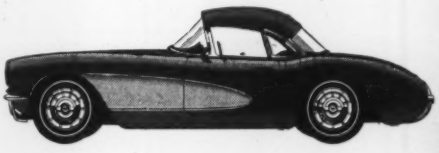
Some of these opportunities are for men experienced in solving problems of semiconductor processing, development, or application. Other positions are for persons experienced in semiconductor or related research.

These are challenging jobs where professional knowledge will be utilized to the highest degree. Qualified persons will be rewarded with personal satisfaction, recognition and stimulating companionship with other eminent scientists, and will also receive liberal compensation and benefits as important members of the General Motors organization.

If you are capable of assuming the responsibility of leadership and are experienced in transistor, diode, photo cell or other semiconductor projects, write to Personnel Director, Department H. Your inquiry will be held in confidence.

WORK WITH THE MEN WHO FIRST MADE HI-POWER TRANSISTORS AVAILABLE IN AUTO RADIOS!

Relocation expenses are paid to pleasant Indiana community where you'll make congenial associations with men of recognized standing in the field of semiconductors.



GM
GENERAL MOTORS

Delco Radio

DIVISION OF GENERAL MOTORS, KOKOMO, INDIANA

—ITEM 577—
For More Information Circle Item Number on Yellow Card—page 19
Facing Page—ITEM 578→

THE shape of things to come is often seen in the aluminum extrusions being made by Revere for the country's manufacturing leaders. These are the companies that know how great a difference may exist between the design of a new shape on paper and the delivery of a fine extrusion in aluminum. They come to Revere for the experience and service needed to bridge this gap. It will pay you, likewise, to gear the progress of your business to the most dependable sources of supply.

Revere Aluminum Mill Products include extruded shapes, tube, rod and bar; coiled and flat sheet, embossed sheet, circles and blanks; seamless drawn and welded tube; rolled shapes; electrical conductors; forgings; and foil. Call the nearest Revere Sales Office now. In all principal cities. Revere Copper and Brass Incorporated. Founded by Paul Revere in 1801. Executive Offices: 230 Park Avenue, New York 17, N. Y.

(Advertisement)

★ Control Components Digest ★

News and notes on resistors, rheostats, relays, motor controls, dimmers and other control components

SYLVANIA'S SOFT BLUE MERCURY VAPOR LAMPS are seen on many modern thoroughfares. Integral Ward Leonard resistor in each lamp contributes to reliable operation.

Improved mercury-lamp design features sealed-in resistor

Seal it in and forget it, for the lamp's life of 6000 hours plus!

That's the way engineers at Sylvania Electric Products Inc., Salem, Mass., treat the current-limiting resistors in their modern, improved mercury-vapor lamps.

And, naturally, for the heavy-duty, heat-, moisture- and ultra-violet-proof starting resistors, to be sealed up in these lamps, Sylvania engineers chose Ward Leonard Vitrohms.

These rugged resistors not only take the temperatures (to 750°F), but are immune to the heavy vibration encountered on or near bridges, ramps, railroad crossings or heavily-traveled highways.

Why not let a Ward Leonard engineer show you how Vitrohms can solve your resistor problem. Write today for complete information.

NEW MINISTRIP RESISTOR

New miniature power resistor

A new 20-watt Ward Leonard "Ministrip" resistor is now available.

Recommended where space is limited, but where no sacrifice can be made in quality, the new resistor features low, built-in mounting brackets (2-5/16 in. between centers) and an oval-shaped core for maximum strength.

Stock resistance values to 50,000 ohms; 5% tolerance.

Failure-free parts key to system reliability

Roughly speaking (and skipping a lot of mathematical subtleties) if you double the number of parts in a complex system—other things being the same—you'll cut in half its life expectancy.

The modern trend is toward more and more complex jobs for electrical and electronic gear. Doubling—and more—the number of parts goes on all the time. And yet it's vitally important that overall system reliability not be impaired.

That's why at Ward Leonard you'll find such painstaking attention devoted to increasing the reliability of our products. From incoming raw material to finished part, our careful attention to every phase of production and every inspection and test assures you of a product you can count on in *your* system.

CHECKING CONTACT PRESSURE on a Ward Leonard relay—one of the many 100% inspections and tests that assure its final quality.

USS FORRESTAL. Photo courtesy Newport News Shipbuilding and Dry Dock Company.

MAG-A-TROL for USS FORRESTAL

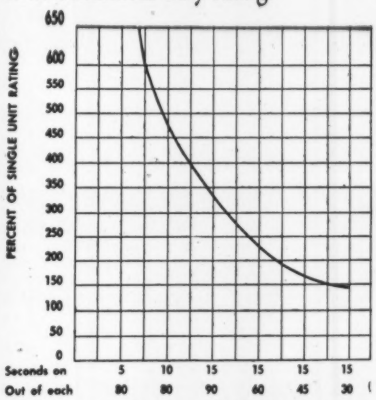
Precision-controlled lights guide pilots to the flight deck of the USS Forrestal, largest aircraft carrier.

The new carrier uses Ward Leonard magnetic-amplifier-type dimmers to insure correct light intensity on the flight deck at all times.

Besides the Forrestal's magnetic amplifier dimmers, Ward Leonard makes *all* types of lighting controls (autotransformer, reactance and resistance) for fluorescent or incandescent lamps.

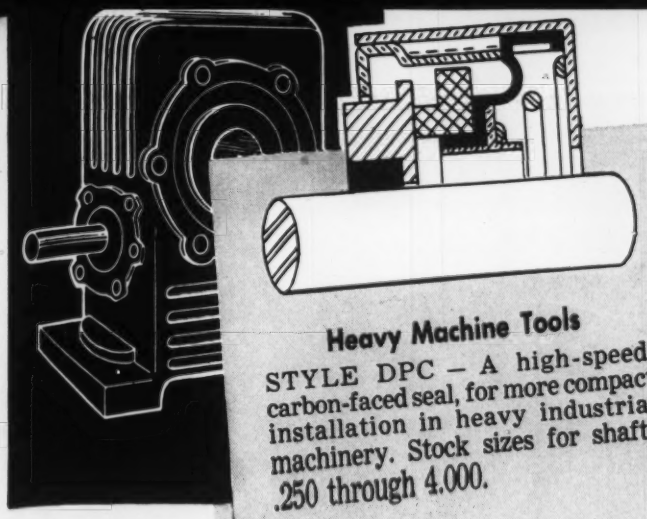
Design aid for intermittent duty

A power resistor used only intermittently may be used at wattages in excess of its continuous-duty rating.



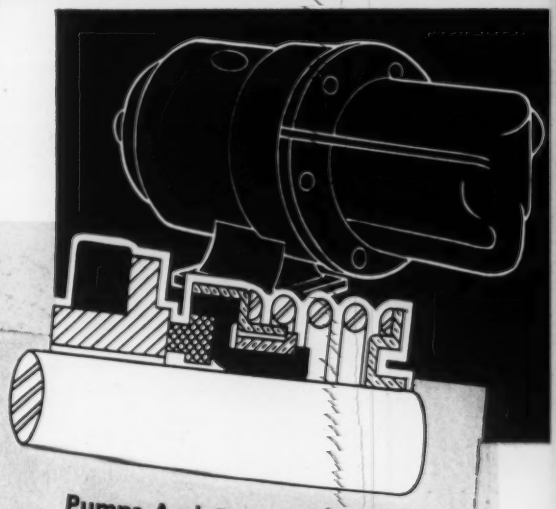
The curve above will help designers figure allowable dissipation increases for Ward Leonard Vitrohm and Ribflex resistors for various duty cycles. Assumed maximum temperature rise: 375°C; resistor spacing: 2½ in. This is one of many useful curves contained in our 64-page Catalog #15—ask for it today. 6.7

WARD LEONARD ELECTRIC COMPANY
58 SOUTH ST., MOUNT VERNON, N. Y.
Result-Engineered Controls Since 1892
RESISTORS · RHEOSTATS · RELAYS · CONTROLS · DIMMERS



Heavy Machine Tools

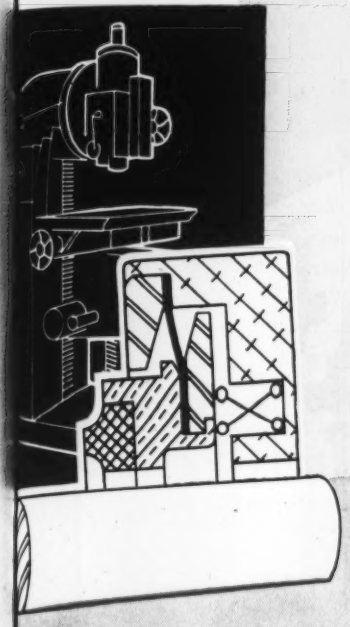
STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Machine Tools And
wer Transmission Equipment

YLE GU — A packaged sealing t containing both rotating and tionary seal faces enclosed in tal housing. Stock sizes for shafts 0 through 4.000.

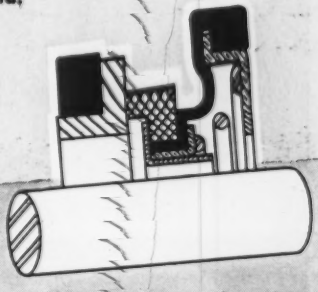
A Complete Line
GITS SHAFT SEALS
For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

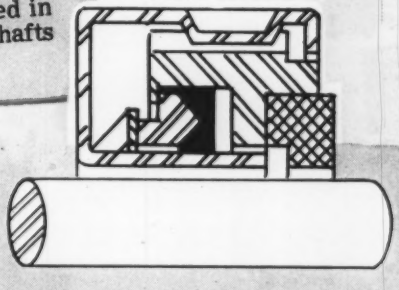
1868-A South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



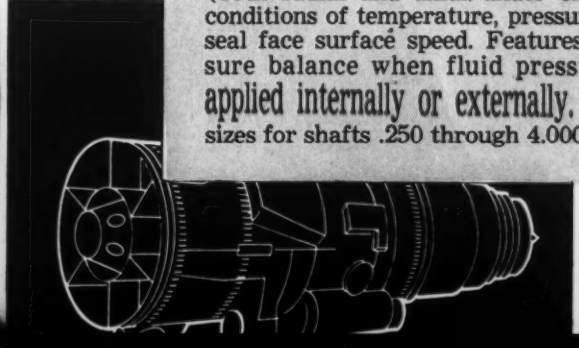
Household Appliances

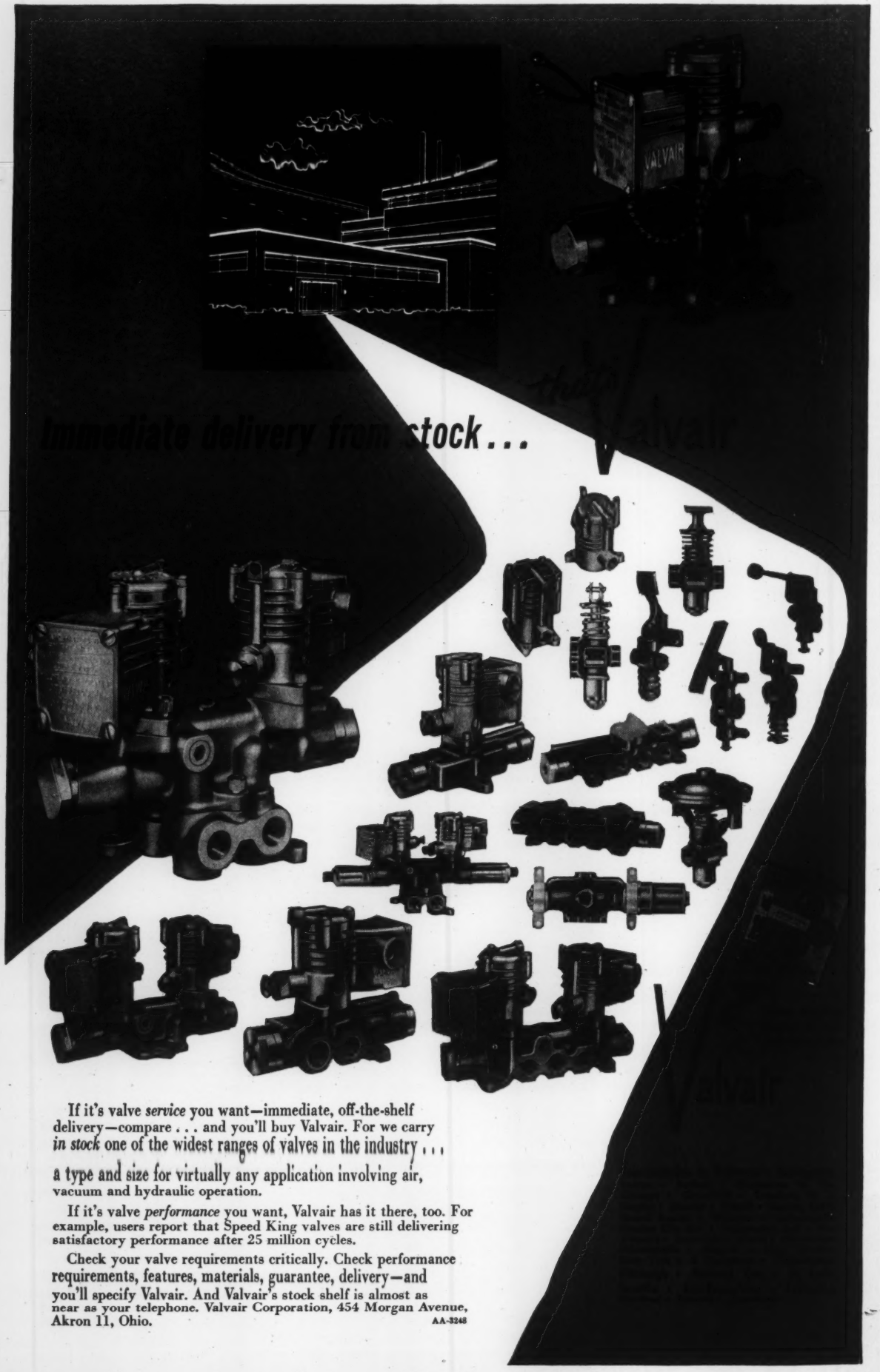
STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.





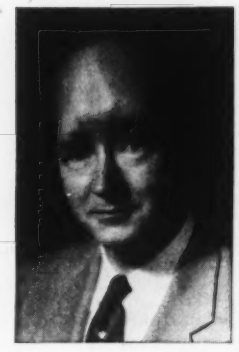
If it's valve *service* you want—immediate, off-the-shelf delivery—compare . . . and you'll buy Valvair. For we carry *in stock* one of the widest ranges of valves in the industry . . . a type and size for virtually any application involving air, vacuum and hydraulic operation.

If it's valve *performance* you want, Valvair has it there, too. For example, users report that Speed King valves are still delivering satisfactory performance after 25 million cycles.

Check your valve requirements critically. Check performance requirements, features, materials, guarantee, delivery—and you'll specify Valvair. And Valvair's stock shelf is almost as near as your telephone. Valvair Corporation, 454 Morgan Avenue, Akron 11, Ohio.

AA-3248

MACHINE DESIGN
JUNE 14, 1956



Nor Any Drop To Drink

ENERGY let loose by the mightiest H-bomb is puny indeed alongside that which controls the weather. And recently the weather seems to be on a new rampage of violence—hurricanes in the east, tornadoes in the midwest, torrential rains in the west. We cannot altogether rule out the possibility that man may some day be able to divert or moderate a storm, but any basic control of the weather pattern seems out of the question.

With every storm our dependence on machines is brought home with increasing force. The sad fact is that floods—the dreaded aftermath of most storms in the areas of highest population and industrial concentration—are poison to practically any machine. Production machinery in manufacturing plants, household appliances in homes, automobiles on the highways—all can be temporarily or permanently put out of action by a few minutes of submersion in water or even by heavy splashing.

Prevalence of this kind of damage is well recognized by the insurance companies. They are not interested in insuring against flood damage and will do so only for a high premium. So much hardship has resulted from this situation that the federal government may have to go into the insurance business.

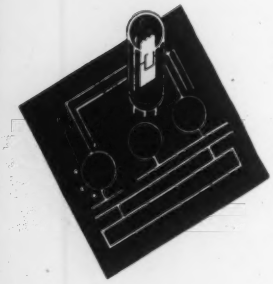
In the absence of weather control or of adequate protection against loss, the design engineer has a marvelous opportunity to step in and perform a great service. Water damage need not be as crippling to machines as it so often is. The materials of construction—metals, plastics, ceramics—are themselves quite impervious to water. Protective coatings can prevent rust. Moving parts can be enclosed and sealed against moderate water pressure and silt. Electrical elements can be "potted" or otherwise protected by plastic coatings. And so on.

As a design objective, any machine or appliance that has been immersed in muddy water should be capable of restoration to service after only partial dismantling, a good hosing down and a reasonable drying procedure. One must have lived through a flood to appreciate the esteem in which the manufacturer of such a machine is held.

Design engineers seeking a new challenge need look no further.

Colin Carmichael

EDITOR



Designing Electronic Equipment

Design of electronic equipment sets the pattern for ease of maintenance. Often, relatively small expenditures of time and money in the design phase can result in large savings in future maintenance costs.

General procedures and steps for designing electronic equipment for maintainability are covered in this article, the first of a group that will appear in MACHINE DESIGN. In future articles, a host of design ideas and suggestions will be presented as an aid in designing electronic equipment for both preventive and corrective maintenance. For example, the following subjects will be covered in detail: Designing equipment in units or sections, covers and cases, interconnecting conductors, connectors for cables and wires, accesses, test points, controls, color coding, and related topics.

Original material for these articles was prepared, under Air Force contract, for the Psychology Branch, Aero Medical Laboratory, Wright Air Development Center, Dayton, O.

MAINTAINABILITY is a measure of the speed and ease with which preventive maintenance can be performed or equipment malfunctions diagnosed and corrected. Maintainability can be distinguished from reliability, which is a measure of the average length of time equipment operates without malfunction. Reliability has long been recognized as an important virtue in electronic equipment design, but users are now also beginning to look for maintainability as one of the primary design attributes.

The continuing trend toward more complex military, industrial, commercial and domestic electronic equipment is making potential customers keenly aware of the need for high maintainability. For example, in automated assembly lines, easy maintainability is a critical requirement because of the almost fantastic costs of "down time." Built-in maintainability is an important way to minimize maintenance costs and expensive down time.

Specifications of maintainability requirements for electronic equipment are often extremely vague as compared to the detailed performance requirements usually given. Insignificant performance requirements have sometimes been met by employing trick circuits or unusual components that have increased maintenance difficulties. The designer should be encouraged to work out satisfactory compromises between maintainability and performance requirements.

Factors Affecting Maintainability Design

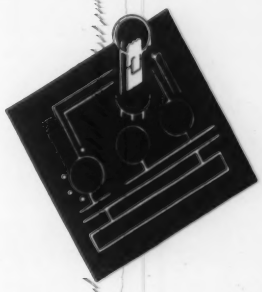
Maintainability design and equipment development are integrated processes. Basically, good maintainability requires (1) self-checking features or test points for external checking to permit trouble shooting down to each replaceable or repairable unit in the equipment, and (2) easy access to test points and to units to be replaced, repaired, adjusted, or serviced.

Meeting these design requirements demands systematic consideration of the following factors throughout development of the equipment.

Appropriate Test Equipment: This auxiliary equipment must be suitable for checking those functions of the prime equipment that are not self-checking. It must be available for all levels of maintenance. Ruggedness, accuracy, size, weight, and complexity of operation must be considered.

Effective Maintenance Procedures and Diagrams: These procedures and diagrams should contain only the necessary and sufficient operations for adequate maintenance. They should contain only information needed to perform those operations. They should be tailor-made for each level of maintenance and, of course, should be published when the equipment is first available.

Recommended Personnel Requirements: Descriptions of maintenance job activities are derived



for Maintainability

By John D. Folley Jr. and James W. Altman
Research Scientists
American Institute of Research
Pittsburgh

directly from the procedures. The personnel requirements implied by these procedures should be compatible with personnel available to do the job.

Proper Tools: The requirements for tools are another direct derivative of the procedures. Special tools should be developed concurrently with the equipment.

Work and Storage Facilities Required: This is an important part of maintenance cost and should be kept in line with facilities likely to be available.

Plans for Overhaul, Modification, and Supply: Field service facilities will require full information on how to provision spares, have equipment overhauled, and keep up to date on modifications made for product improvement or for increased production efficiency.

Effective Installation: A high degree of maintainability in electronic equipment may be largely nullified by an incompatible or undesirable installation. The final product should be compatible with likely installation limitations.

When to Design for Maintainability

The preceding factors must be considered at specific periods during the development of a piece of electronic equipment. Neglecting or delaying consideration of any one factor may result in decreased maintainability or costly redesign. Therefore, the maintainability design schedule must parallel the equipment development schedule. Basically, maintainability design is accomplished in three phases, namely: (1) planning for maintainability, (2) designing for maintainability, and (3) testing and supplementing maintainability design.

Planning for maintainability involves a certain amount of preliminary work. In this phase the designer profits from the designs of previous equipment by studying their maintainability features and maintenance experience or history. Design objectives should reflect the results of this study.

Design for maintainability is the crucial phase in deciding the quality of the final product. It must be well under way by the time functional diagrams, unit specifications, and schematics are in process of preparation if redesign is to be avoided. The following activities are included in this phase:

1. Grouping of components on chassis and subchassis.
2. Design of controls, displays, accesses, test points, outside covers, and connectors.
3. Preparation of maintenance procedures for each maintenance level.
4. Specification of tool and test-equipment requirements, and development of special items not commercially available.
5. Study of layout and wiring diagrams to determine whether all components are accessible for maintenance and whether test points, adjustment points, and accesses are provided where needed.
6. Tryout of maintenance procedures on a nonfunctional mock-up for preliminary test of both the procedures and the maintainability of the configuration.
7. Testing of procedures and maintainability on the developmental model when it becomes available.

Testing and supplementing maintainability design involves testing developmental and production models. These tests of maintainability duplicate, insofar as possible, the conditions under which production equipment will be maintained. This means employing only those procedures, tools, and test equipment that will be available to the maintenance man. It is also important that maintenance personnel selected to make these tests not be more highly trained than the maintenance personnel who

will likely be assigned to maintain the equipment in the field.

The tests should consist not only of running through routine procedures but should also include trouble shooting a variety of malfunctions. Emphasis of the tests should be on finding ways to improve prime equipment, test equipment, tools, clarity of instructions, procedures, or combinations of these. These improvements should be incorporated in production units.

How to Design for Maintainability

This method of designing for maintainability is based on two assumptions: (1) the designer will have available diagrams that show which manufactured parts will go into the system and how they will be electrically connected, and (2) the designer will be familiar with plans for use of the equipment to predict maintenance limitations.

Maintainability must be incorporated in the original design of equipment. Opportunities to change equipment for improvement of maintainability largely disappear after the equipment is released for production. The following steps permit systematic consideration of essential maintainability features during model planning and development stages.

Step 1—Specify maintenance levels and general requirements.

In the practical field situation, maintenance usually has to be done in steps so that the equipment system can be kept in operation a maximum proportion of the time. Quick emergency replacement may be a necessary first step, followed up by repair activity on the replaced item.

Maintenance levels usually will fit into the three general categories of customer maintenance, field service, and factory service. The general requirements for maintainability at each level depend upon functional demands on the system. For example, extremely rapid customer maintenance may demand development of elaborate automatic test equipment. These functional demands are the primary criteria for maintainability design. However, economics, supply of components, personnel training, and engineering feasibility must also be considered.

Step 2—Divide equipment into units for maintenance at each level.

Units to be replaced by customer maintenance must first be specified, and these units divided into units replaced by field service. These in turn are divided into units replaced by factory service, with the smallest nonrepairable (throw-away) unit specified.

The final division of the equipment should be the result of careful compromises among the following items:

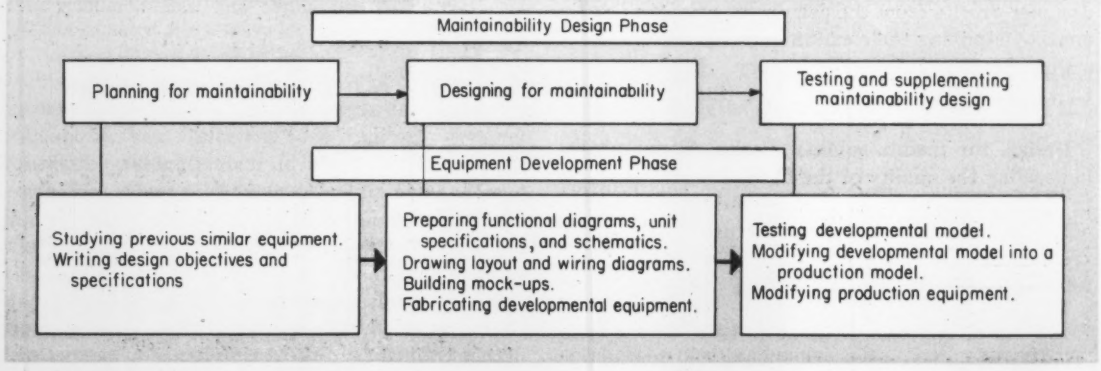
a. General maintenance specifications prepared in Step 1.
b. Detailed considerations in the design of the actual hardware, or units, for maintainability.
c. Sound engineering practice.
d. Economic considerations.

Characteristics of the customer maintenance replacement unit are controlled by the requirement that the customer's technician will be able to perform all required maintenance within practical time limits. Trouble-shooting time is of primary concern here.

The equipment unit to be replaced by field service is most strongly affected by cost of various kinds of spare components, training requirements implied by the various functional sizes of units. requirements for tools and test equipment, and the procedures needed.

Cost is the chief factor in determining the characteristics of the throw-away unit for factory service. If the cost of facilities for trouble shooting and repairing a given level of units exceeds the cost of providing a new unit for each one that fails, those units should be throw-away units. On the

Phasing Maintainability Design with Equipment Development



other hand, if the maintenance costs are relatively low and the units are expensive, the units should be repaired when they malfunction.

Step 3—Prepare maintenance procedures.

Maintenance procedures must be prepared for the system as a whole, and for each unit at each maintenance level. Customer maintenance procedures should be prepared first, since they are influenced by operational requirements more than the other two levels. Field-service procedures and then factory-service procedures should follow.

It may be helpful to group the procedures for each level into the following categories to minimize the chances for omitting necessary items:

a. Checking.
b. Trouble shooting.
c. Adjusting.
d. Replacing.
e. Repairing.
f. Servicing.

These maintenance procedures are the cornerstone of all of the maintainability design details to be built into the equipment later and should be organized according to known principles of procedure design. Demands for test equipment and tools should be reasonable. Special test equipment and tools will not be available when the procedures are written. The designer thus has the opportunity to prepare "ideal" maintenance procedures bounded only by the reasonableness of the demands they place on auxiliary equipment, prime equipment, and maintenance personnel capabilities.

Step 4—Extract maintenance support requirements from procedures.

Each procedure must be analyzed step by step, standard job supports must be listed, and nonstandard items described in detail.

Requirements should be extracted for the following items, and collated into an integrated list:

a. Prime equipment characteristics: special controls, indicators, and connections; test points; special constructional configurations and installation features.
b. Test-equipment characteristics.
c. Bench mock-ups or test stands.
d. Tools.
e. Readings and tolerances needed to perform procedures.

Step 5—Review maintainability requirements.

Maintainability requirements are checked for compatibility with themselves and with operational requirements, and for reasonableness of demands on test equipment and personnel requirements.

The following three factors must be considered in reviewing these requirements:

a. Can the requirements be met within the budget and time limits of the project involved? Meeting certain requirements may require development of special test equipment or tools, or elaborate tests to obtain realistic check values.
b. Are the characteristics of resulting test equipment realistic for field use where appropriate? Extremely delicate and sensitive test equipment may be rapidly degraded if, for example, it is used regularly in a factory production-line environment where vibration and dirt are present.
c. Will it be feasible to train personnel to use test equipment meeting these requirements? Equipment demanding high skill levels reduces the number of people capable of doing the job.

Some modifications to maintainability requirements may be necessary to stay within the many limits set up by operational requirements, personnel considerations, etc.

Procedures, design of equipment and job supports, and maintenance levels are interdependent. Modification of any one may require modification of others to meet the requirements of reasonableness and compatibility among themselves.

Step 6—Translate requirements into equipment and job instructions.

Fabrication of hardware and preparation of job instructions completes the maintainability design of the developmental model. The design is now ready to be tested and supplemented as necessary.

Future articles will present specific recommendations for maintainability design.

Maintainability Design Steps

Step 1—Specify maintenance levels and general requirements.
a. List operational requirements.
b. Decide maintenance levels.

Step 2—Divide the equipment into units for maintenance at each level.
a. Divide equipment into customer-maintained units.
b. Divide customer-maintained line units into field-serviced units.
c. Divide equipment into factory-serviced units.

Step 3.—Prepare maintenance procedures for each unit at each level of maintenance, and for the system as a whole.
a. Enumerate the procedures.
b. Prepare the procedures.
c. Review the procedures for conformance to maintainability recommendations.
d. Review the procedures for conformance to operational requirements.

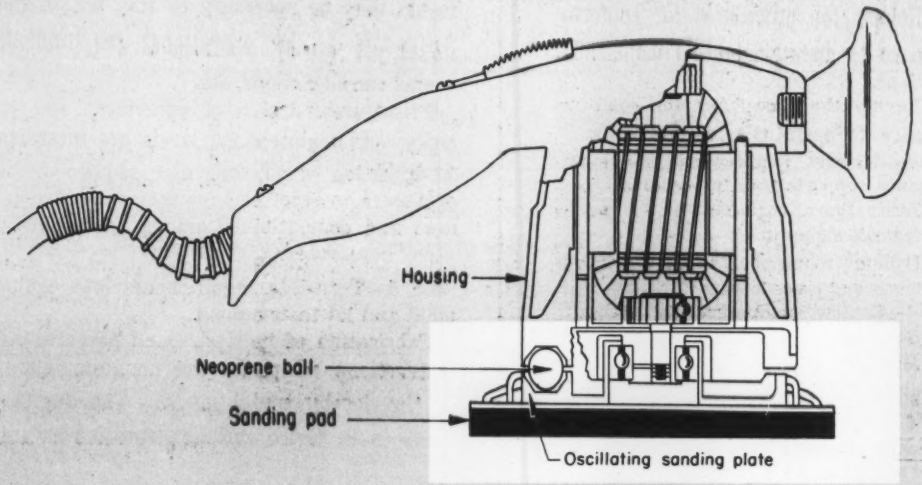
Step 4.—Extract requirements for maintenance supports from procedures.
a. Write down requirements for maintenance supports.
b. Collate requirements from various levels and procedures.

Step 5—Review maintainability design.
a. Review for reasonableness.
b. Modify maintainability design as required.

Step 6.—Translate requirements for maintenance supports into actual equipment and maintenance instructions.

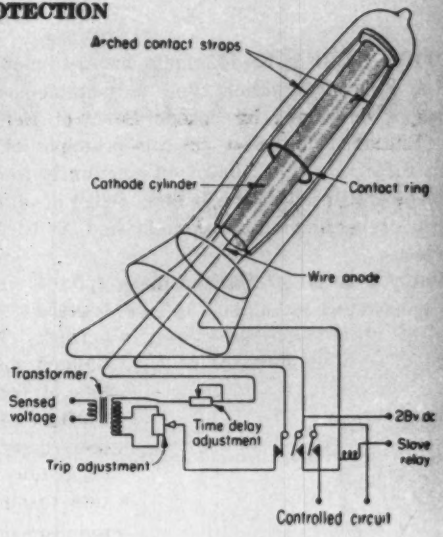
scanning the field for Ideas

RUBBER-BALL MOUNTING of oscillating plate members minimizes effects of vibration and reduces operating noise. Serving both as thrust and roller bearings, four ½-inch diameter Neoprene balls are employed in the design of a portable electric sander developed by Thor Power Tool Co. One ball is located at each corner in cavities between the sander housing and the oscillating plate, and these provide the cushioning effect.



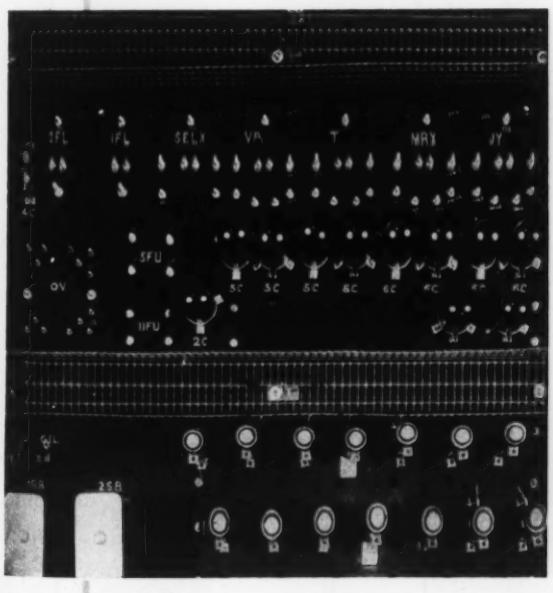
Overvoltage protection

in ac or dc circuits is provided by a novel relay design that is thermally operated. The breakdown or ionization voltage of an inert gas is used to sense an overvoltage condition and the heat developed by current flow through this gas, after ionization, is employed to operate a thermal switching element connected to a tripping circuit. Developed by Jack and Heintz to sense overvoltages in ac aircraft generators, the relay, because of the principle of operation, is unaffected by altitude and acceleration, and requires no rectifier or separate power supply.



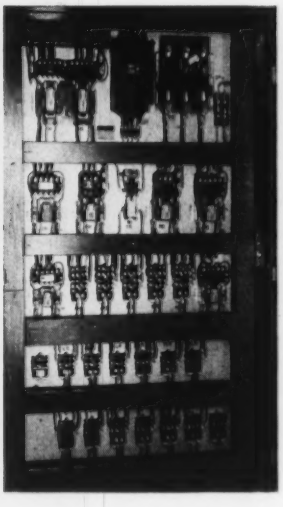
In construction, the relay consists of a hollow, cylindrical metal cathode with a wire anode positioned in and along the cathode axis. Two arched-metal straps are mechanically fastened to the ends of the cathode, and a contact ring is attached to one strap. All of these components are sealed in a glass envelope filled with an argon-neon gas mixture.

At low or normal-voltage conditions, the metal straps are electrically isolated from each other and from the cathode. At a predetermined value of overvoltage, however, the gas breaks down, producing a glow discharge, and current flows between cathode and anode. The current flow heats the cathode and causes it to expand. As the cathode elongates, it stretches the arched straps until both touch the contact ring operating a control circuit.



Multiple-circuit wiring

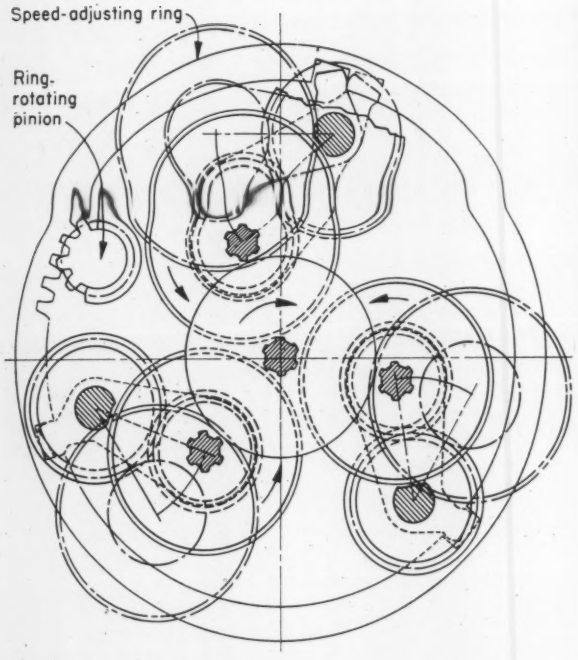
of electrical and electronic assemblies is facilitated by channels constructed of plastic-coated wire mesh. Developed by F. L. Teuscher of General Electric for electric control panels, the channels provide a large number of exits to meet varying design conditions. The wire-mesh channel design prevents distortion from heat. The plastic coating provides an insulated channel member and protects the electrical wiring against abrasion.

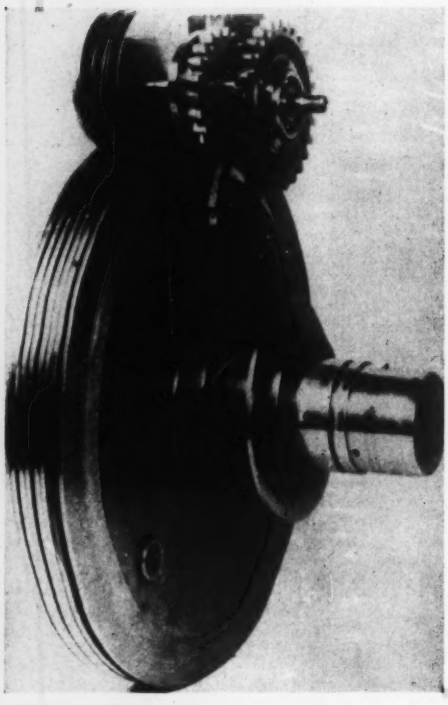


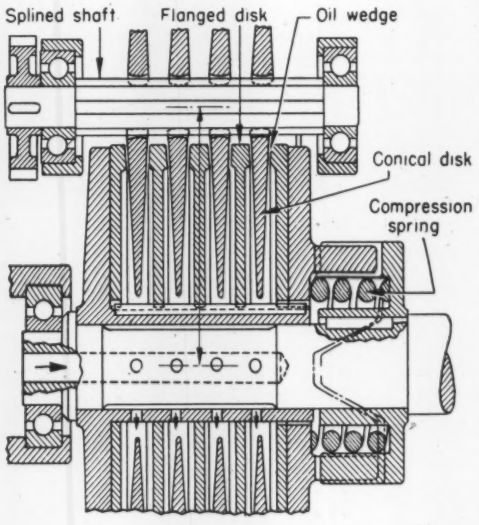
IDEAS

LIQUID FRICTION SURFACES eliminate metal-to-metal contact and assure quiet operation in a novel "traction type" adjustable-speed mechanical transmission. The design developed by Joseph Beier of Beier Infinitely Variable Gear Co. Ltd. (England) is based on the principle of torque transmission through the drag force in a thin film of oil constantly interposed between driving and driven members. In operation, a long wedge of oil is formed between the rotating members, preventing actual contact and, in turn, wear of the power transmitting surfaces.

In the assembly is a set of flanged disks splined on a shaft and pressed together by a compression spring. Meshed with these flanged disks are one or more sets of conical disks splined on shafts. Arrangement of the flanged and conical disks can be readily interchanged in design to suit varying application requirements. Speed is adjusted by mechanically changing the "amount" of mesh between the flanged and conical disks. The contact radii of the conical disks are thus varied while those of the flanged disks remain constant. Under overload the disks will slip, permitting operation of the assembly above rated capacity. However, efficiency decreases and heat generation increases under overload. Efficiencies of more than 90 per cent are possible under certain operating conditions.







Men and Machines

. . . an informal history

By R. S. Hartenberg and J. Denavit*
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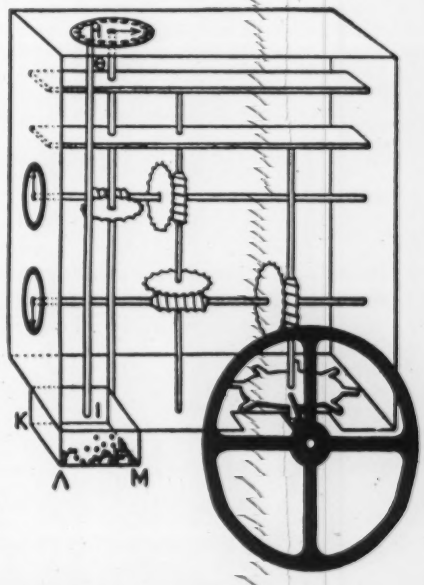
Northwestern University
Evanston, Ill.

This excursion into the past began in the May 3 issue. It treats of the origins and developments of machines and mechanisms in relation to other human affairs.

THE DRIFT of our treatise now turns to a useful invention of the greatest ingenuity, transmitted by our predecessors, which enables us, while sitting in a carriage on the road or sailing by sea, to know how many miles of a journey we have accomplished." The engaging device of which Vitruvius (born B. C. 85 or 75) is here speaking is the (h)odometer,[1] a distance-recording device. It has a gear-train of four wormwheels driven by a gear itself actuated by a single tooth on the axle of a wagon (or the axle of a paddled wheel projecting from the side of a ship). The first models had pointers on three appropriate shafts (like our present electric meters) to indicate the "mileage" and fractions thereof. By Vitruvius' time the improved model dropped a pebble through a hole into a metal drawer every "mile." Vitruvius ends the chapter by saying: "I have described things that may be provided for use and amusement in times that are peaceful and without fear." Vitruvius wrote mainly as an observer of past practice. His service to posterity was in reducing the past to writing, and then having the luck to have his works preserved.

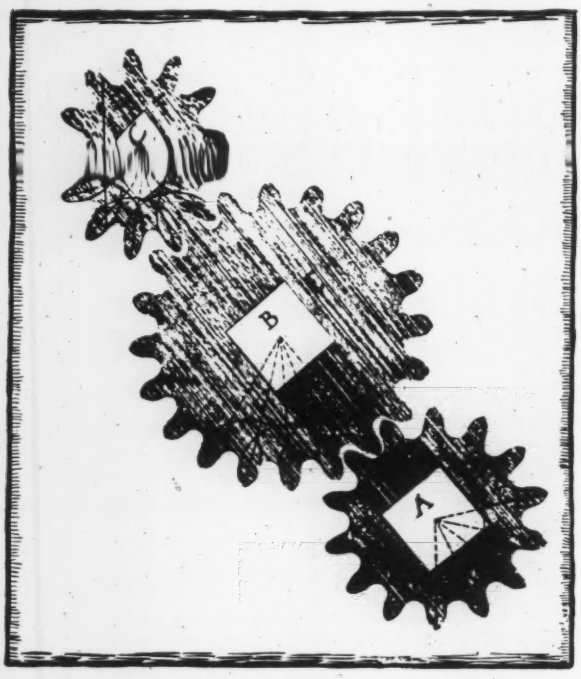
The combination of poor tooth form, inadequate materials and rude construction methods produced speed ratios in the early gears whose average and instantaneous values were far from identical. The first scientific examination of the proper tooth form seems to have occurred in the 17th century, when Desargues (1593-1662) developed the cycloidal form. The suitability of the involute form was demonstrated by de la Hire (1640-1718). The lack of machinery and ignorance of workmen in many areas found gearteeth for another century



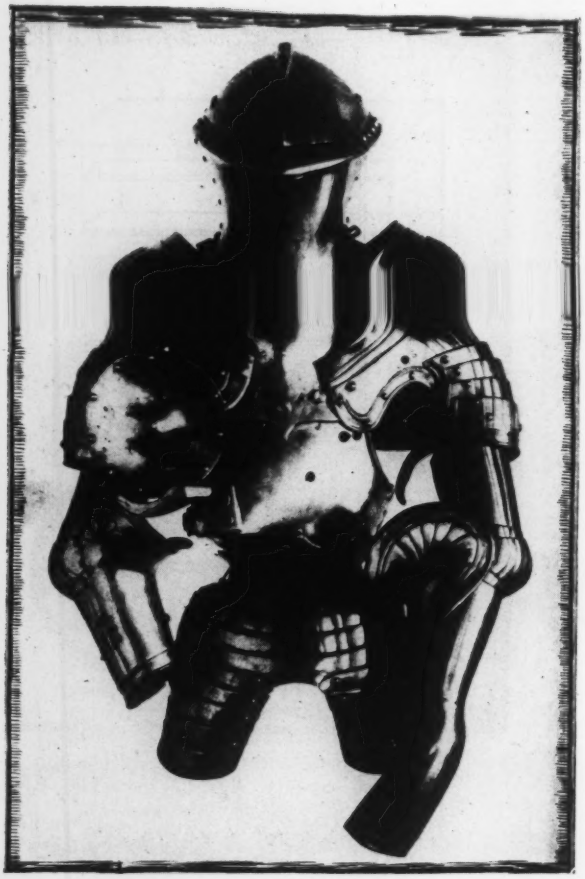
Odometer described by Vitruvius, first century B.C. (From Diels)

[1]In its modern form it is called a cyclometer, is fastened to the front axle of a bicycle, and is still driven by means of a single "tooth" fixed to one spoke. As part of a speedometer, the drive is by flexible shaft.

*Now, French Air Force.



Tooth profile suggested in 1558. These gears were to be used in the drive of an armored vehicle, crank-driven by its personnel. (From Feldhaus)



Early armor, held together by rivets, leather belts and thongs. This suit from Nuremberg exhibits screw fasteners, modern for 1498. (From Treue)

or so being laid out by eye—"no rule but the eye in the formation of teeth"—as in the English gear practice of 1837. But among those who knew, the involute form was applied to power gearing in the early 19th century, although the cycloidal form, or its modifications, is still applied in the light gear trains of watches and instruments.

The screw, for all its brilliant start and ingenious applications in the pre-Christian era, was to have a low use factor before it became the common and inexpensive fastening device or the precision measuring component we know so well.

Screw fasteners were apparently not used by the Greeks, and to only a limited extent by the Romans. In fact, the screw was not used for structural purposes, but as a clothes fastener—a long screw thrust through the fabric and turned into a nut. And even this disappeared from the scene after the 6th century; it was lost and forgotten for approximately a thousand years.

Before the screw was developed as a fastener, it was principally used to exert pressure, as in wine and oil presses. These screws were carved from wood. From Pompeii's excavations (the destruction occurred in 79 A.D.), it is clear that single and twin-screw presses were in use during the first century. A metal surgical instrument for expanding body openings was found. It made use of a screw and nut to force open, through a linkage, the jaws of the instrument.

We may reflect on the fashioning of the screw, hand-cut in wood or metal, and the difficulty of making the nut. Often the nut had only a part thread, as a peg or flat plate, that engaged the thread of the screw.

Aside from the hand-filing of screw threads, the wire-and-solder technique was developed in Roman times, and is said to be still practiced in the remote parts of the East. To make a nut and bolt, two wires would be wrapped around a mandrel; one wire and the rod to which it was subsequently soldered formed the bolt; the second wire, soldered into a circular hole in a piece of metal, produced the nut of sorts. The wire-soldering scheme was used mainly by goldsmiths for both ornamentation and fastening during the next several centuries preceding the Fall of the Roman Empire (476). During the Dark Ages—a European monopoly—the use of the screw was confined to the Arab and Greek artisans who used threaded components in such things as surgical devices and timekeepers.

ALTHOUGH European contact was established with the East through the first Crusade in the 12th century, it was not until the Renaissance that the screw reappeared as a useful object in Europe. By the 15th century suits of armor began to show a screw fastening or two, replacing leather straps. Metal screws of bronze or iron

came into fairly common use in the next century for the pressure elements of printing presses and jacks for overthrowing masonry. The medievalists applied the screw to other persuaders in which fine shadings of pressure were wanted, as in the torture instruments known as the boot and thumbscrew.

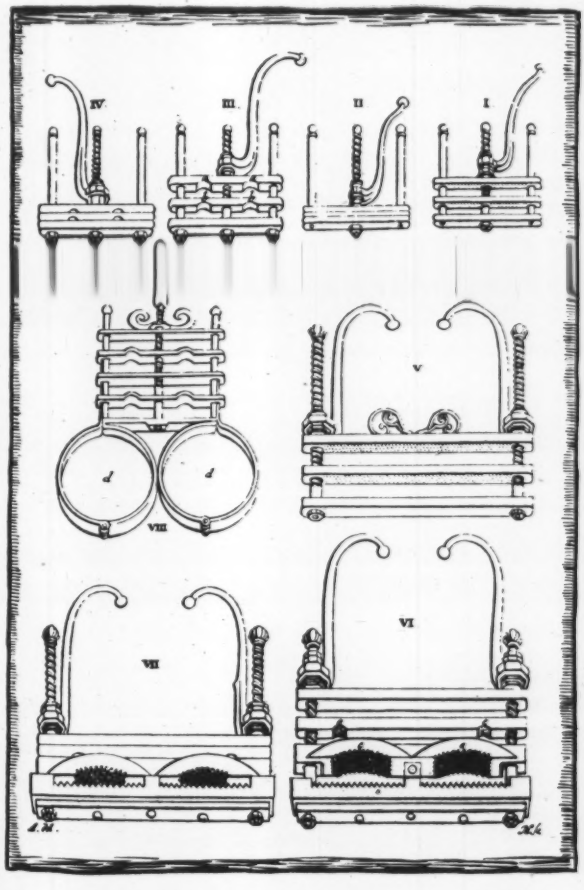
Agricola's account of the mining industry of the 16th century noted the use of the screw for both boring tools and fasteners. Da Vinci's notebooks contain sketches of screw-cutting machines that did not get beyond the design stage, for hand production methods continued to supply the wants for nearly three centuries. A crude chasing tool was described in France by Besson in 1569, but it remained an isolated tool, and another 150 years or so had to pass before screw-making machinery replaced hand-filing. And even then, since the machine was dependent on its own inadequate leadscrew, hand-filing was resorted to when increased accuracy was required.

It was in England, in 1750, that the first factory for screw making was established. Another half-century elapsed before cottage industry yielded to the machine, and the woodscrew became pointed.

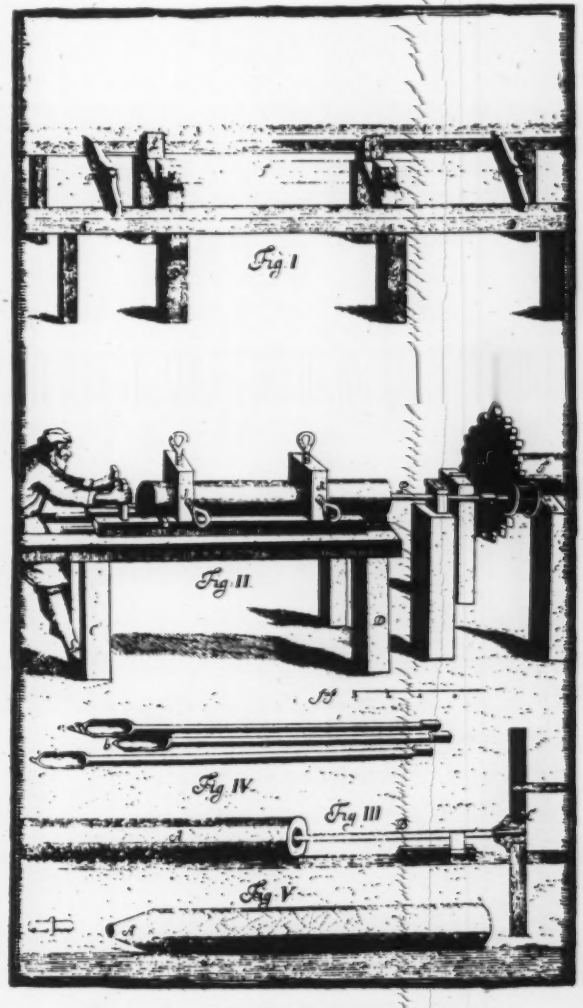
The Industrial Revolution (18th century) with its demand for machinery—driving and driven—made a cheap and accurate threaded fastener a necessity. Accuracy, however desirable or important, was unknown, for with the hand-filing methods a nut and bolt were a pair mated for life, since they would fit only each other. Interchangeability[1] was unheard of, for there were no standard proportions, each shop having its own ideas about lead and diameter.

It remained for Henry Maudslay (1771-1831) to make the first good leadscrew; he spent some ten years in laying out, chipping, filing, checking. From this 7-foot long screw he was able to make others on his rigid iron lathe (previous lathes were of wood). Maudslay devised the change-gear box for the lathe, a really significant and far-reaching invention, for with its use a given leadscrew could cut a great variety of threads instead of merely reproducing itself. Standardization of threads appeared first in Maudslay's shop; it was made a reality for all of England through the

[1]Interchangeability as a concept seems to have been a French idea, but its vigorous development and use in the United States caused it to be known in Europe for many years as the "American system" of manufacture.



Torture instruments. Thumbscrews, I-V; boot, VI and VII; thumbscrew with leg-irons, VII. (From Treue)



Boring mills for wooden pipes, 18th century. The power "could come from water, horses or treadmill." (From Leupold)

efforts of Sir Joseph Whitworth by about the mid-19th century.

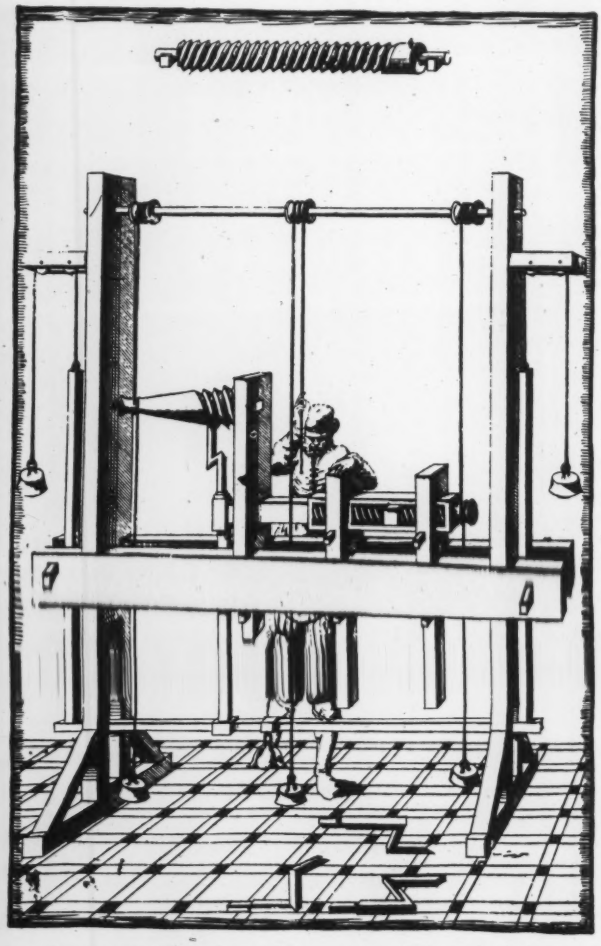
The practical application of the screw form to marine propellers[1] seems to have been first made by John Stevens in 1804. As first tried, the screw was somewhat like that of Archimedes' but without the encircling case. An accident caused part of the helix to break off, giving a bladed propeller whose advantages were recognized and further exploited.

THE beginning of the Christian era saw a substantial number of devices constructed from combinations of the five "simple machines," or, more accurately, from combinations of the six mechanical components. Theory, at least in the hands of a few, enabled the calculation of the approximate mechanical advantages of such combinations and the establishing of gear ratios for certain tasks. Most practical achievements were, of course, founded on empiricism. The peak of perception and ingenuity had been reached by the Greeks some time before. With the Roman conquest of Greece in B.C. 146 innovation and development came to a halt, even the Roman engines of war becoming inferior to the earlier models.

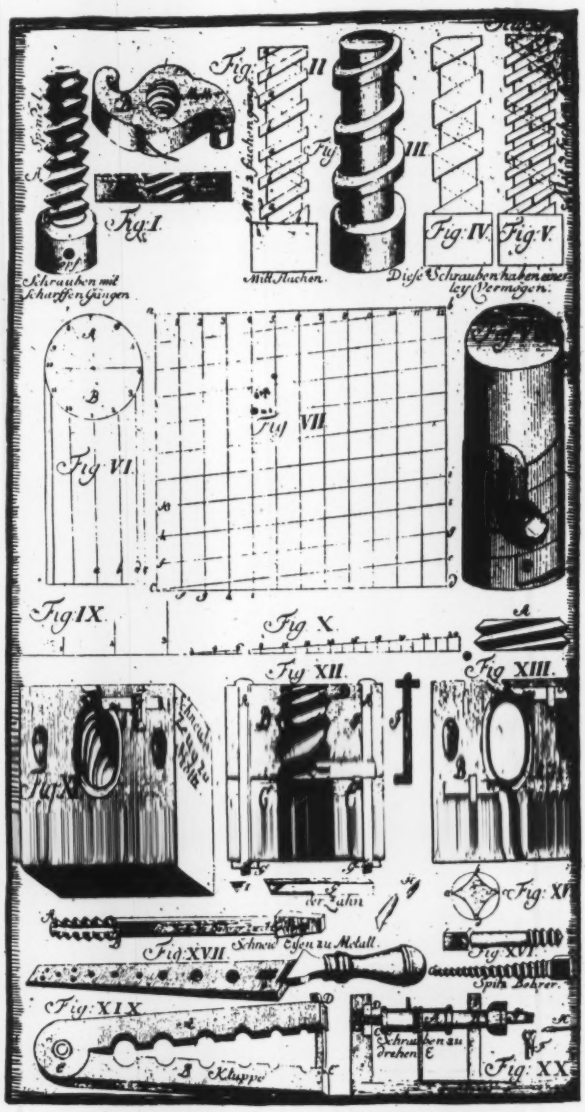
The next few centuries were indeed barren. Wars and civil wars, plagues, corruption, outrageous taxation,[2] a decreasing birthrate, the extensive use of slaves and the inflow of adventurers brought the Roman Empire to hard times. The Empire continued only because it was held together by inertia. The arts and literature declined, and those who read at all relied on collections of quotations instead of a study of the classics. Science stagnated, and deferred to unreasonably inaccurate compendia and manuals. The shifting political sands allowed no growth. Great garrisons were necessary in the occupied areas, and the army's strength lay in the German mercenaries.

Roman conquests included most of present-day England, France, Spain, Italy, western Asia and even the northern portion of Africa. Britons, Gauls, Iberians, Italians, Egyptians, Arabs, Jews and Greeks were under the sovereign rule of Rome. Most of Germany had not yielded, the barbarians[3]

[1]The first submarine, the *American Turtle*, used for the protection of New York harbor in 1776, had a hand-driven screw propeller of Archimedean type.
[2]For example, in a Roman military camp in Syria the commander's records for the year 113 A.D. show that the men working the Archimedean pumps paid taxes of over 17 per cent of their income!
[3]Barbarians: any of the nations not part of the Roman Empire.



Screw-cutting lathe, 16th century. Workpiece is at left, leadscrew to right. (From Besson)



Screw layouts, taps, and dies for wood and metal, 18th century. (From Leupold)

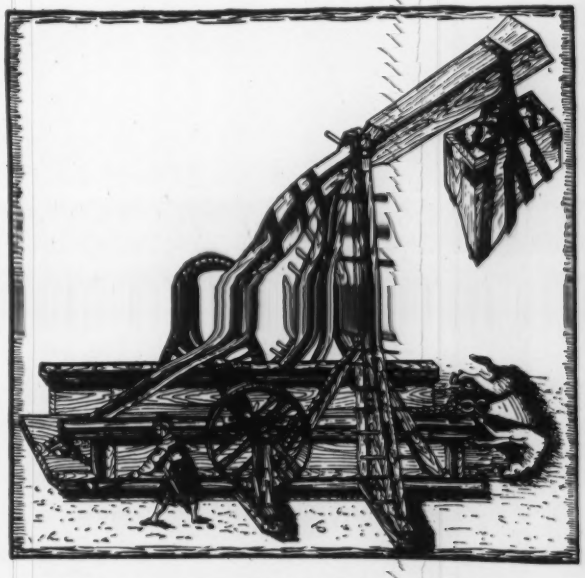
being contained by fortifications and guards along the Rhine and Danube. For a time these measures were successful in preventing the violent occupation of Roman territory. A new pressure developed when the Huns, a Mongolian tribe from central Asia, forced the Goths, who were settled along the Danube, across the river into Empire limits. This breach of the boundary was the beginning of the end, for in 410 A.D. the city of Rome was taken by the Goths. Other German tribes took over in Gaul, Spain, Italy, northern Africa and Britain. The confusion caused by the influx of the Germanic tribes was great and it was compounded by the Huns who now penetrated into western Europe; Venice was founded by the refugees from Lombardy. The Huns were defeated by the Romans and German inhabitants of Gaul in 451, and after the death of their leader Attila a year later never again troubled Europe, vanishing completely. On the other hand, in 476 a German general banished the last of the emperors of the West (i.e., in Rome, as different from the emperors of the East, in Constantinople). This year of 476 is commonly taken as the date of the "Fall"[1] of the Roman (western) Empire and the beginning of the Middle Ages.

With the withdrawal of the Roman legions around 410, the Britons suffered from the raids of the Scots and the Picts until the Teutonic invasion by the Angles, Jutes and Saxons in the middle of the 5th century. The resistance was stout; the legend of King Arthur comes from the 6th century. The 9th to the 11th centuries saw the Northmen or Vikings (Danes and Scandinavians) exploring, harassing England and the continent. Iceland and Greenland were colonized in the 10th and 11th centuries; the Danish supremacy of England was accomplished in 1042. The Northmen also gained a permanent foothold on the Seine; the region is now called Normandy. In 1066, William, Duke of Normandy, completed the subjugation of the Anglo-Saxons in Britain. Two nationalities and two languages existed side-by-side for many years; the king and nobles were French Normans or French. Crusaders came and went (Richard the Lionhearted died in 1199). In 1215 the barons forced the Magna Charta, which reaffirmed and strengthened the foundations of the security of English political and personal liberty.

At any rate, Europe was in a state of turmoil which was to leave it almost completely savage. Mystical chaos, states of constant warfare and danger did not encourage the study of science, the reading or writing of books or any attention to art. Europe had entered the Middle Ages—the Dark Ages[2]—a period of about a thousand years between the fifth and sixteenth centuries. The great centers of learning—Alexandria, Carthage, Rome, Milan—had been partially destroyed by one invader or another. Christian enthusiasts had burned libraries kept in the temples of the pagan gods, and even the great school in Athens had been closed for lack of funds. Only the simplest and homely skills were maintained, the mechanical devices of the ancients being nearly all forgotten or lost in the melee, having to be reinvented at a later date.

An interesting weapon, the trebuchet, appeared in the 12th century. It operated on the principle of main strength and awkwardness rather than mechanical refinement. The dimensions of one example are astonishing. A 50-foot beam was pivoted at about the quarter-point on a horizontal axis some feet above the ground. To the short end about 20,000 lb of weights were secured, and the long end was then hauled down by block and tackle to touch the ground. To this end a sling was attached, and when the long end was released from the tackle it swung up and whipped the contents of the sling into the air. Stones of 200-300 lb could be thrown about 300 yards to batter at fortifications, which they did with considerable success. As a variation, dead soldiers[3] and horses were thrown into besieged towns with the hope of creating a pestilence.

During the 12th century the crossbow was the subject of armament talks. It was argued that the crossbow caused such barbarous wounds that it was proper to use it only against infidels—the first Crusade[4] having been mounted in 1096. The Lateran Council interdicted its use in 1139 under penalty of an anathema as "a weapon hateful to God and unfit for (use against) Christians". The prohibition was later confirmed by Pope Innocent III; the emperor of Germany, Conrad III, himself a leader in the second Crusade, forbade the use of the crossbow in his army and kingdom. However, by 1200 the employment of crossbowmen was



Trebuchet to cast dead horse into besieged town. Original drawing is in da Vinci's *Il Codice Atlantico.* (From Payne-Gallwey)

[1]The "Fall" of which Gibbon wrote *The Decline and Fall of the Roman Empire.*

[2]"Dark" in continental Europe. The Arabs kept the lamps of science burning. In Europe, this period might be likened to gestation, a preparation for later events.

[3]". . . he must be tied up with ropes, so as to form a round bundle like a sack of grain."

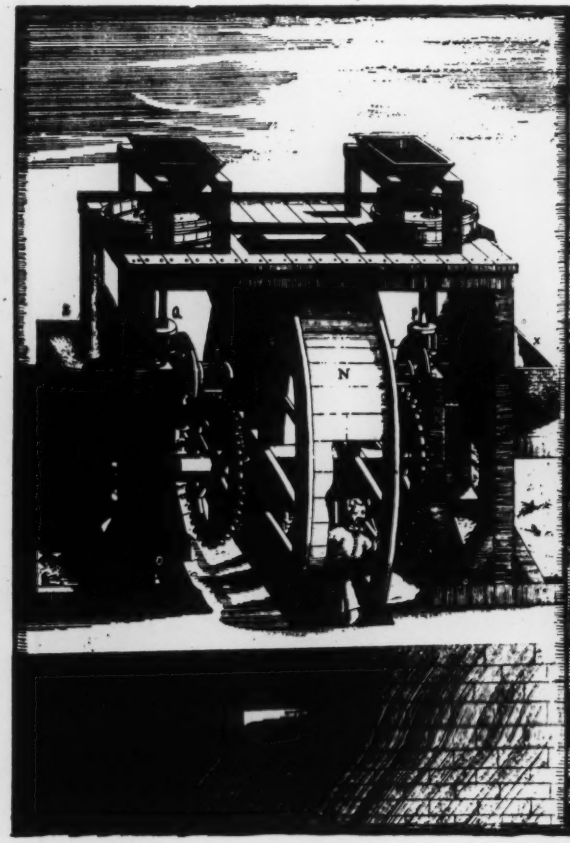
[4]The Crusading fervor swept Europe for 200 years, producing ten separate expeditions.

common in the English and Continental armies.[1] The crossbow remained a popular weapon for more than two centuries, its compactness making it highly useful in the close quarters of a besieged castle. It was displaced by the long bow, which had a greater range and five to six times the rapidity of fire.

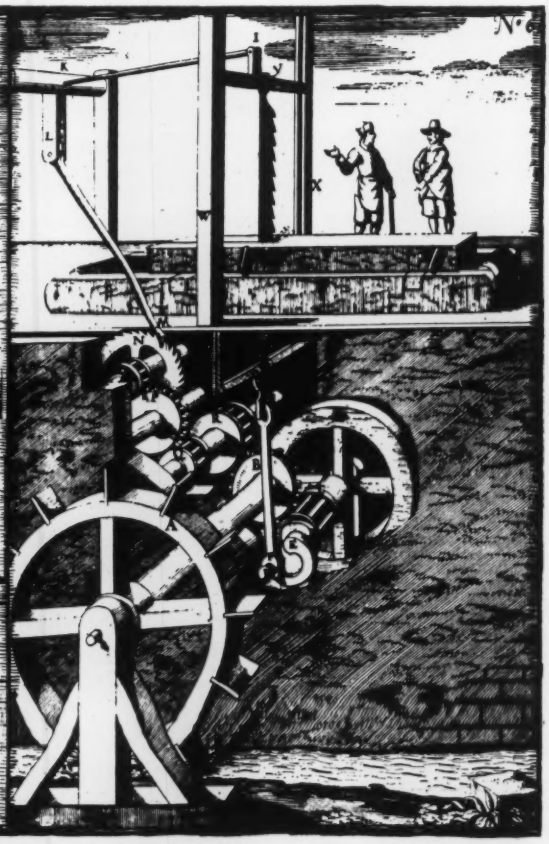
[1]For example, it is reported that 15,000 crossbowmen formed the front rank of the French army at Crecy in 1346. This was the first major engagement of the Hundred Years War (France and England).

Crossbowmen operated in teams to have continuous firepower while "reloading." The man in the center is winding up his windlass crossbow. The original drawing is in Froissart's *Chronicles,* 15th century. (From Payne-Gallwey)

WITH changing social and economic forces, sources of power other than human were developed, the earliest being water wheels, animal power and windmills. The early water wheels of various forms were used principally for raising water through the use of integral buckets, as different from using the rotating shaft to drive sophisticated machinery. The water wheel of which we usually think is one in which the shaft power was applied to grain mills, saw mills and trip hammers; these were later developments. Wheels with bucketed peripheries were also built to raise water from one level to another; the shafts were turned by animal power (horses, cattle, humans) moving in either a circle (as in turning a capstan) or working on or in treadmills. The windmill is first mentioned by an Arab geographer who saw them in Persia during his travels in the first half of the 10th century. There is evidence that the windmill was also developed independently in Europe, for there were many in Northern France and England at the close of the 12th century, i.e., before the Crusaders "discovered" the East.



Treadmill design, 1661. (From Boeckler)



Design for water-powered sawmill, 1661. (From Boeckler)

Responding to the resurgence of learning that preceded the Renaissance, universities began to appear on the European scene. Salerno's school of medicine dates from the 9th century; the universities of Paris, Oxford and Cambridge from the 12th. After this the number of universities increased steadily. Most were under the tutelage of the Catholic Church, but after the Reformation many became independent of the Church. The first Protestant university was Marburg (1527); it was soon followed by others.

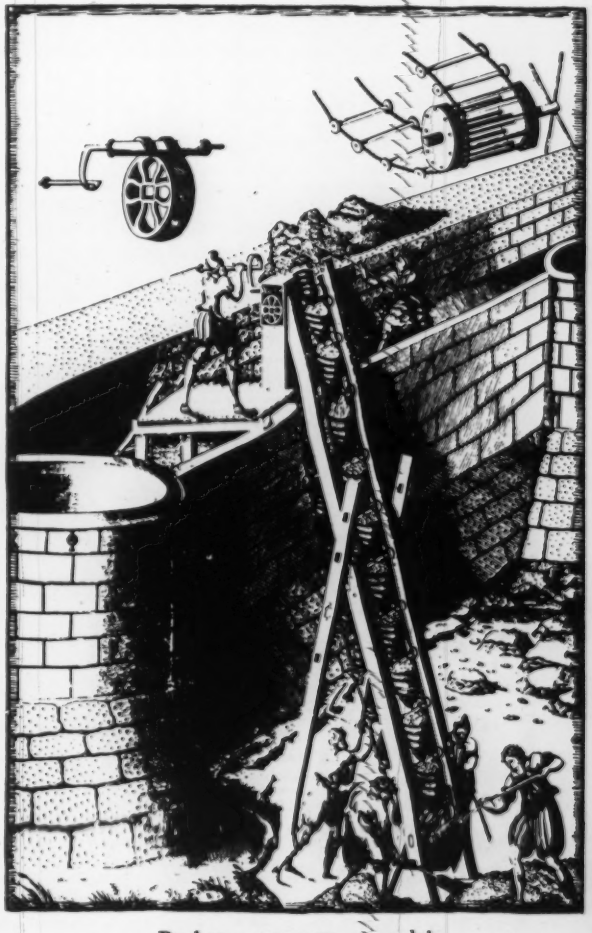
The late Middle Ages, say between the 12th and 16th centuries, produced a glorious period in European art. The revival of classical learning stimulated a vigorous activity in the arts, literature and humanities. From Italy to England, from Spain to Bohemia, paintings, tapestries, illuminations, cathedrals and stained glass windows appeared in rising numbers. Among the cathedrals of older date are Westminster Abbey (begun in 1045), and Notre-Dame de Paris (begun in 1163). We note, however, that society was sharply divided, for the peasants lived in miserable villages around the great cathedrals. The rebirth of the humanities was confined to a certain level, was confused, and was great.

During the 14th century the ravages of the Black Death (the plague, an acute, malignant infectious disease still found in Asia) wiped out at least one-quarter of the population of Europe. The first translation of the Bible into English (from the Latin) was rendered by Wycliffe in 1382-84. The Hundred Years War between France and England (1339-1453) seems, from the start, to have involved the cannon as a new weapon.

The 15th century, like the others, was marked by contrasts. Joan of Arc, captured and condemned for sorcery, was burned at the stake in 1431 toward the end of the Hundred Years War. Gutenberg's invention of the movable type led to the printing of the Bible in 1450, and opened the means for the spreading of knowledge by the manifold reproduction of books. Da Vinci,[1] the great engineer-artist of the Renaissance, discovered much of the mechanical past anew. His notebooks are filled with sketches of an extraordinary number of mechanical devices, (including roller bearings) of which only some were new ideas, as a weight-driven clock with hour and minute hands. Their execution was often proscribed by the ma-

[1]Da Vinci (1452-1519), a man of many talents, (*Mona Lisa, Last Supper*), lived first in Florence under Lorenzo de Medici who was poet, scholar and patron of the arts and literature. He went to Rome to become military engineer to Cesare Borgia, the cardinal and military leader. A few years before his death he went to the court of France.

A spring engine of medieval times for shooting arrows. Note that the elevation could be changed by raising the front prop. Original drawing is in *Vegetius*, edition of 1607. (From Payne-Gallwey)



Bucket conveyor, model 1569 A.D. (From Besson)

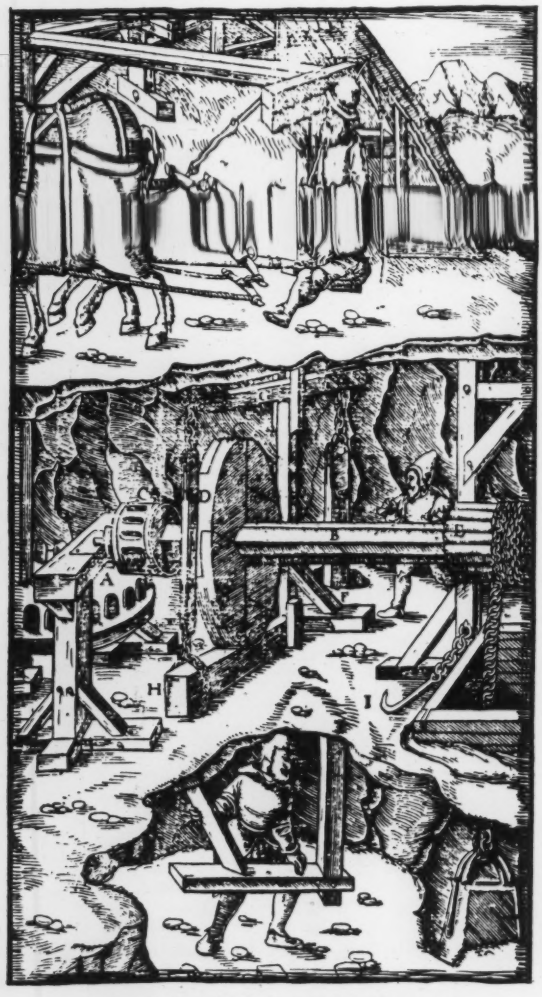
terials of the times. The last half of the century was a time of incomparable artistic production and scientific searchings — Michelangelo, Titian, Raphael, Durer, Copernicus and Columbus were contemporaries.

Before the 15th century ended, the New World was added to man's horizons by Columbus, and Vasco da Gama rounded the Cape of Good Hope. Thoughts of riches and colonies led the way to the wars of exploitation and conquest that were soon to follow. The discovery of the Americas found primitive peoples as well as highly developed social and political groups. In some places massive structures, rivalling those of ancient Egypt, had been built with only the barest mechanical aids. None of the American civilizations had developed the wheel. The most potent native weapon was the bow and arrow, and it was pretty poor in comparison with the English longbow, which was itself inferior to the older Turkish bow.

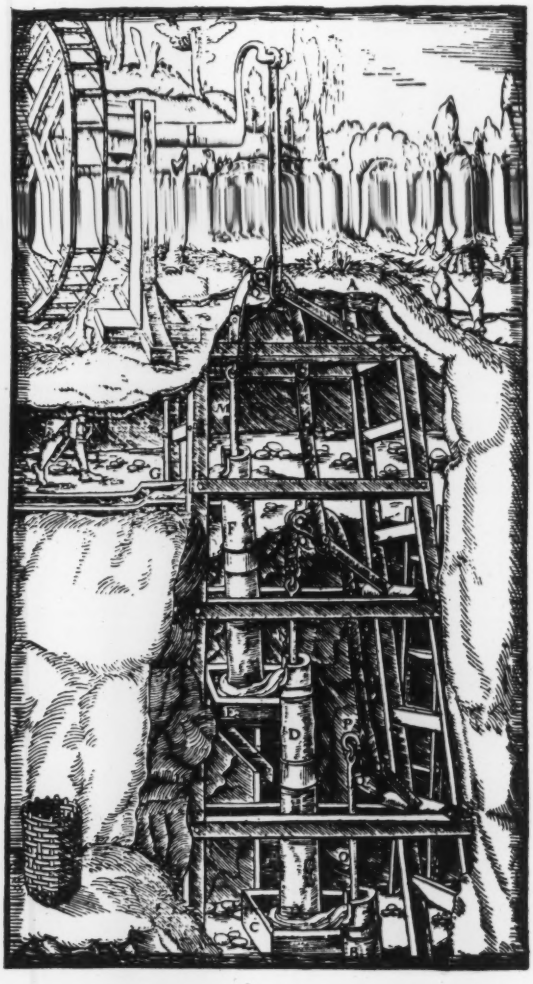
The first quarter of the 16th century saw the globe circumnavigated by Magellan during 1519-1522. During the same period in the New World Cortez conquered Mexico ("death of the Montezuma"), and went on to discover California in 1526. Pizarro explored and conquered Peru ("the last of the Incas") over the period of 1524-1532. Martin Luther, priest, professor and doctor of theology, initiated the Reformation in 1517; this was followed by extended wars of action and reaction to Protestantism. Spanish, French and English colonies were established in the Americas; the first slave voyage by the English brought 300 Negroes to the West Indies in 1563. The Roanoke colony vanished to an unknown fate in 1587.

The turbulent century furnished the setting for Elizabeth, the Virgin Queen (1558-1603), the defeat of Spain (Armada) in 1588 at the hands of Drake, and the rise of England as the world's principal power. New things stirred the world—voyages to distant places, colonization, and an outpouring of literature never before equalled; Shakespeare (1564-1616) was Elizabeth's contemporary, and so was Sir Walter Raleigh, who promoted the colonization of America.

The 17th century found a group of one hundred colonists — either gentlemen or criminals, with hardly any laborers—established at Jamestown in 1607, to be followed in 1620 by the Plymouth settlement. Swedish and Dutch colonies were ven-



Mine hoist of 1556, one horsepower and one-wheel brake. (From Agricola, Hoover translation)



Three-stage pump (1556) operated by linkwork and driven by water wheel. (From Agricola, Hoover translation)

tured, as when Peter Minuit purchased Manhattan Island in 1626, and founded the settlement of New Amsterdam. Europe was in a state of religious and political turmoil, and the Thirty Years War (1618-1648) left it shattered. Here, at one time or another, England, the Netherlands, France, Sweden and German Protestants were arrayed against Spain, Italy and German Catholics. The character of the war was, of course, not wholly religious. Power politics and the annexation of territory were great factors in deciding the alliances of the struggle. It was fought mainly in Germany, and the effects of the war—exhaustion, impoverishment and decimation—were felt most keenly there, and prevented that country from making any considerable contribution to the culture of Europe until the end of the 18th century.

THE 17th century was, however, the age of re-enlightenment. It accomplished a deep cultural, philosophic, scientific revolution. Descartes, whose Latinized name became the label for his Cartesian co-ordinate system, lived 1596-1650. Newton's span was 1643-1727, and his German contemporary Leibniz, who also worked on the differential calculus, flourished 1646-1716. Of this time, too, was Robert Hooke, to whom the Hooke's or universal joint is ascribed, a point of dispute with some who hold that it should be called the Cardan joint after the Italian mathematician of the 16th century. The middle of the 17th century was a time marking the beginning of the great era of scientific thinking and experimentation that has continued with an ever-increasing tempo. The mathematical tools were being developed—without them, progress would have been impossible, and would have had to continue to follow the slow perceptive path of the past instead of being able to analyze, deduce and predict.

During the Renaissance, some small mechanization had been accomplished, but generally speaking it was limited in its application to the grosser tasks of grinding grain and pumping water, either out of mines or for municipal purposes. The cam and linkwork were being exploited during the 16th century by the heavy industry of the times, mining. Agricola shows cams (or approximations) operating piston pumps, stampmills, bellows, and trip (or tilt) hammers.

Inquiry into the shaft horsepower available from the several common sources reveals only modest quantities. Not only did muscle and wind power represent small inputs, but all of the motion-transforming machinery was saddled with inherently high mechanical losses, a trouble further compounded by the structural design specified by the building materials of the time. This last was the dominant feature that prevented the largest source of power, water, from being used effectively. Approximate values of the horsepower from different sources follow: man at crank, 1/12 to 1/10; horsegin, 5/8; typical 18-foot overshot waterwheel, 2 to 5; simple or post windmill, 2 to 8; turret windmill (i.e., able to swing into the favorable wind direction), 6 to 14.

The final chapter in this account will appear in a future issue along with an annotated bibliography.

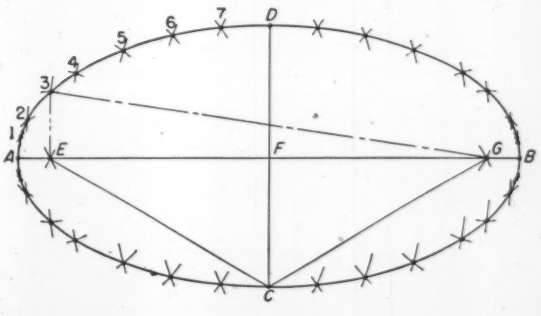
Tips and Techniques

Drawing Ellipses

TO CONSTRUCT an ellipse without using string, first lay out the major and minor axes. In the accompanying sketch, these are *AB* and *CD* respectively.

Locate points *E* and *G* by making $CE = CG = AF = FB$.

Using points *E* and *G*, locate points 1, 2, 3, etc.



by making the distances *E1G; E2G; E3G;* etc. each equal *AB*.

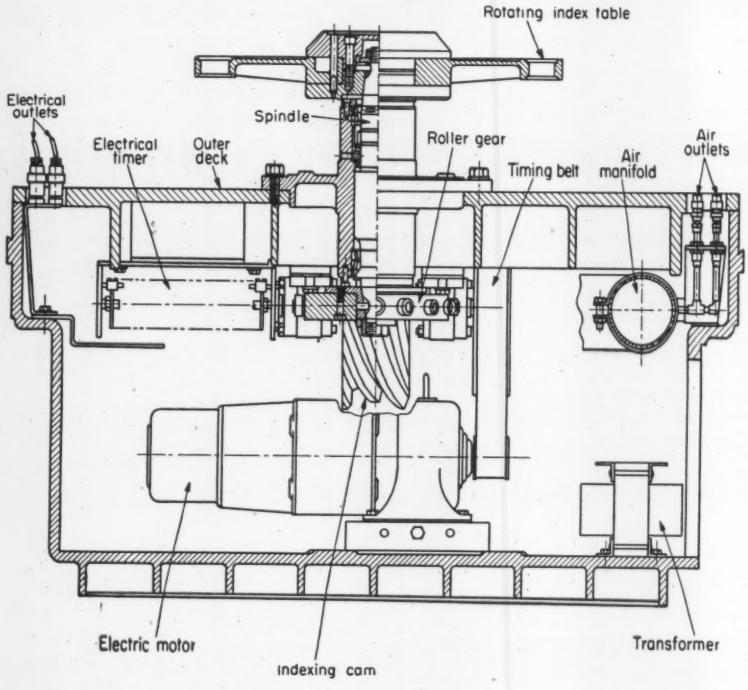
In other words, take a portion of *AB* as the radius of the arc from *E*. Draw this arc. Subtract this distance from *AB* by adjusting the dividers or compass. This remaining length is the radius of the arc drawn from point *G*. The intersection of these two arcs is a point on the ellipse.

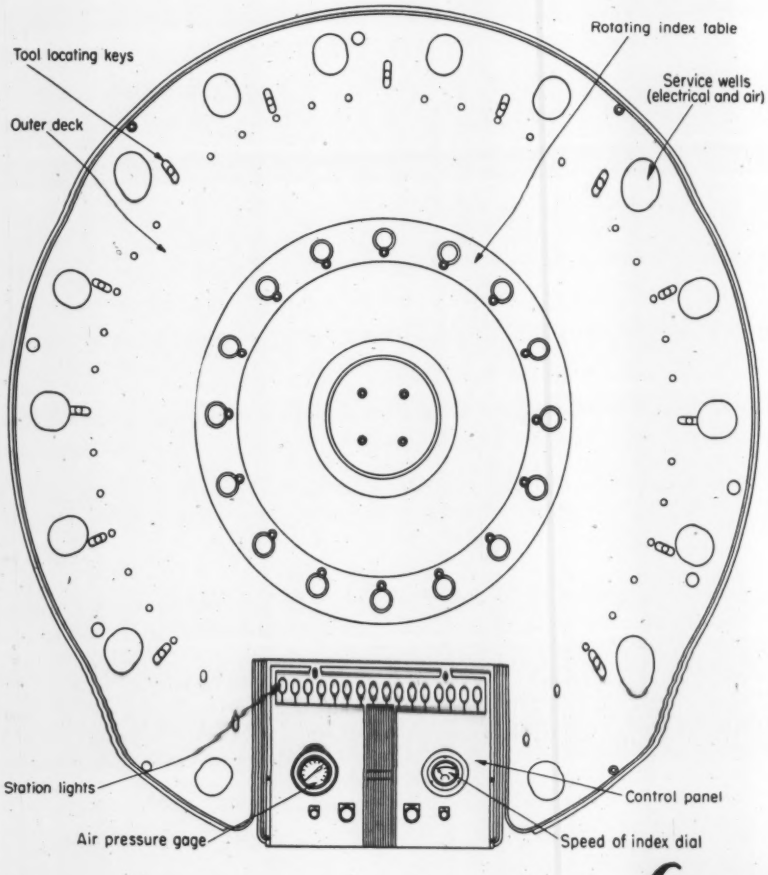
After finding a group of these numbered points, connect them to construct the ellipse.—THOMAS J. PUEGNER, *Halsey W. Taylor Co., Warren, O.*

Making Temporary Deletions on Drawings

Where deletion of a detail or note is only temporary, it can be done by cross-hatching the reverse side of the tracing. Thus, restoring the detail involves only erasing the cross-hatch instead of redrawing the detail. This system also preserves a record of the original details. — HARRY W. VICTOR, *Emerson Radio and Phonograph Corp., Jersey City, N. J.*

AUTOMATIC ASSEMBLING MACHINE





CONSISTING basically of a 6-ft diameter table with 16 tooling stations, a new assembly machine called the Multra may be adapted to a variety of assembly operations. Above and concentric with the main table is an indexing table to receive and transport parts. The machine base contains table drive mechanism, which is a cross-over-type cam and roller gear, drive motor, variable-speed transmission, electrical timer and air manifold. The machine is made by Barnes Engineering Co.

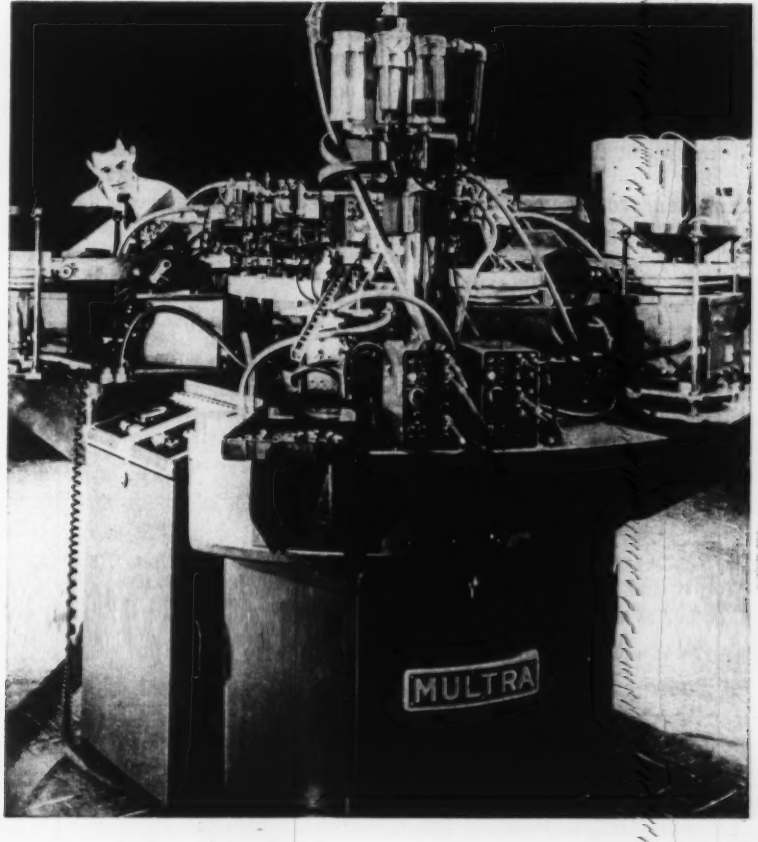
The main table incorporates air and electrical outlets at all tooling stations and tool locating keys which assure accurate position of tooling. Connections from electrical outlets on the table are brought from a master program panel of the patch cord type which permits quick setup for timed control of operations at the various stations. The control panel is contained in the machine base and has a hinged sheet-metal cover for quick ac-

Contemporary

USES INTERCHANGEABLE TOOLING

cess. Start and stop buttons, index speed dial, air-pressure gage and indicator lights for each station are also incorporated in the main control panel.

A tooled Multra machine is now being used to assemble from 15,000 to 20,000 mercury batteries per 8-hr shift by P. R. Mallory & Co. Inc. The machine feeds, sorts, sizes, forms, orients and inspects five different parts. These parts include metal cylinders and caps, felt, and neoprene grommets. In addition, a liquid electrolyte is metered into the battery assembly.



Design

New Standards Aid Selection of

DIE CASTING ALLOYS

NEW METALLURGICAL standards covering compositions and properties of commercial die casting alloys have just been issued.

Eight standards, covering aluminum, magnesium and brass alloys, have been published by the American Die Casting Institute as a part of a continuing standards program (see previous engineering standards, MACHINE DESIGN, May, 1955, Page 153 and November, 1955, Page 162). Later standards will cover zinc alloys.

The new standards represent alloys which are agreed upon by commercial job-shop die casters as standard, although several "special" aluminum alloys are included for particular characteristics. All are considered as acceptable alloys for die casting by members of the Institute.

Information in the set of eight standards includes data on average properties and physical constants, Table 1. Detailed chemical compositions are specified, and a complete cross-index to ASTM, SAE, federal and military specifications is provided. Selection of alloys is discussed. For aluminum alloys, a comparative table of die-casting characteristics, production capabilities, and corrosion and temperature resistance is included.

Aluminum Alloys: Standard alloys, Table 1, are suggested. For particular requirements, the special alloys shown can be used. Usually, higher cost is involved in using the special alloys. Characteristics of the special alloys are:

Alloy 360: better ductility and corrosion resistance than standard alloys. Alloy 39-11: excellent fluidity or die-filling capacity for large, thin-walled, intricate die castings. Alloy 218: best combination of strength, ductility, corrosion resistance and finishing qualities; more difficult to die cast. Alloy 43: enough ductility for forming or upsetting during assembly; difficult to die cast.

Magnesium Alloys: Only one standard alloy is listed, Table 1, although a special low-copper composition may be specified for higher corrosion resistance. It is pointed out that magnesium die castings are lightest in weight and easiest to machine.

Copper-Base (Brass) Alloys: Brass die-casting alloys are readily cast in intricate shapes, but higher temperatures and pressures involved mean comparatively short die life. Thus, costs are relatively higher.

However, brass die castings have the highest mechanical properties and corrosion resistance of all types. Wear resistance and hardness are also high. Particular characteristics are:

Alloy Z30A: general-purpose, lowest cost, 60-40 yellow brass containing tin and lead; good machinability and solderability. Alloy ZS331A: general-purpose alloy of higher strength; easier to die cast but slightly more difficult to machine. Alloy ZS144A: highest mechanical strength, hardness and wear resistance; most difficult to machine; generally used only where high strength or wear resistance is required.

More Information: Copies of the eight metallurgical standards, and of the ten engineering product standards already issued, can be obtained from: American Die Casting Institute, 366 Madison Ave., New York 17, N. Y.

Table 1—Typical Properties of Die Casting Alloys

Type	Aluminum (Std)		Aluminum (Special)				Magnesium	Brass		
Commercial designation (ADCI)	13[c]	380[c]	360[d]	218	39-11	43	AZ91B[e]	Z30A	ZS331A	ZS144A
Nominal Composition	12 Si	3.5 Cu, 9 Si	0.5 Mg, 9.5 Si	8 Mg	3.8 Cu, 11 Si	5 Si	9 Al, 0.7 Zn	60 Cu	65 Cu, 1 Si	81 Cu, 4 Si
Tensile strength (1000 psi)	36	43	43	43	41	30	34	55	70	85
Yield strength, 0.2% offset (1000 psi)	21	25	25	27	27	16	23	30	35	50
Elongation in 2 in. (per cent)	2.0	2.0	3.0	2.0	7.5	5.0	3.0	15	25	25
Shear strength (1000 psi)	25	28	27	28	28	19	20	—	—	—
Fatigue strength[a] (1000 psi)	19	20	19	19	23	17	14	—	—	—
Ultimate compressive strength (1000 psi)	—	—	—	—	—	—	58	—	—	—
Compressive yield strength (1000 psi)	—	—	—	—	—	—	22	—	—	—
Impact strength, Charpy (ft-lb)	—	—	—	—	—	—	—	40	50	70
Hardness, Rockwell B	—	—	—	—	—	—	—	55–60	68–72	85–90
Modulus of elasticity (million psi)	—	—	—	—	—	—	—	15	15	20
Specific gravity	2.65	2.71	2.63	2 70	2 57	2 65	1.80	—	—	—
Density (lb/cu in.)	0.096	0.098	0.095	0.098	0.093	0.096	0.066	—	—	—
Melting point, liquidus (F)	1080	1100	1105	1080	1150	1170	—	—	—	—
Thermal conductivity (cal/cm²/sec/cm/deg C)	0.29	0.23	0.27	0 23	0.23	0 31	0.17	—	—	—
Thermal expansion[b] (in./in./deg F)	11.9×10^{-6}	12.1×10^{-6}	12.2×10^{-6}	$1\ 7\times10^{-6}$	13.9×10^{-6}	12.9×10^{-6}	15.2×10^{-6}	—	—	—
Electrical conductivity (% of copper std)	31	23	29	23	24	37	10	—	—	—

[a] R. R. Moore rotating beam test data at 500 million cycles.
[b] From 68 to 392 F.
[c] Also available with 1.3 max Fe (designated 13X and A380) having 3 per cent elongation.
[d] Also available in lower iron composition, A360.
[e] Also available in high-purity composition (0.10 max Cu), designated AZ91A, having improved corrosion resistance.

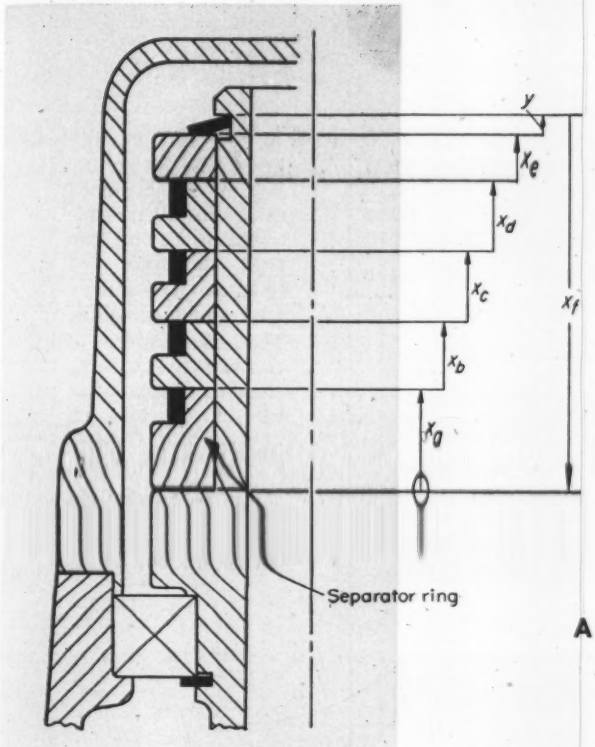


Fig. 29—Slip-ring assembly, with individual dimensions

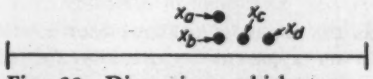


Fig. 30—Dimensions which are probably not independent, since they tend to group about a common value

DIMENSION CONTROL in Design

A systematic study of methods for controlling effects of tolerances and design geometry

Part 5—Probability Dimensioning Methods for Analyzing Mechanism Trains

By Earlwood T. Fortini
Mechanical Engineer
Datamatic Corp.
Newton Highlands, Mass.

DESIGNERS unfamiliar with the concepts of probability theory sometimes tend to make a distinction between mathematical methods that do not use probability techniques, and those that do. There is no reason for this. The role of mathematics in the physical sciences is to form models of real-world situations; the particular form of the mathematics employed is of secondary importance.

Models are constructed by simplifying and idealizing the phenomena under consideration. But no idealized model should be confused with reality itself. A certain model can be associated with an actual situation only if it describes the situation accurately. By means of mathematical models, relationships between two or more connected facts may be studied and new relationships drawn.

Formula given in Parts 3 and 4 are mathematical models developed with the idea that precision and accuracy are defined only in terms of dimension limits. No thought was given to the question: What is the chance of ever getting an extreme combination of limiting values? This question has practical significance only if there is reason to believe that the simplified models do not represent the real situation closely enough.

Suppose that the dimensions of a product had been originally worked out using these models, and that subsequently the dimension limits were altered because close tolerances made manufacture difficult, and therefore costly. If the product functions as well with the new dimension limits, or perhaps even better, it is obvious that the original models did not give a sufficiently accurate description of the real situation.

Thus, while the possibility of extreme dimension conditions occurring should not be altogether ignored, it should not be taken too seriously. Better still, the possibility should be evaluated with regard to the special nature of the problem at hand. To do this, the designer must be familiar with certain underlying principles of probability theory.

Probability theory is applied to engineering problems in many ways. Most of these are not directly concerned with dimension control in design. Some of the applications employ difficult mathematics; sometimes long, tedious computations are necessary. Fortunately, the methods of most value when considering dimension relationships are based on relatively few principles, and require only reasonably brief numerical computations.

The methods shown in Part 3 for analyzing variations in trains of mechanisms and in Part 4 for variations in simple dimension systems are restated in Parts 5 and 6 in terms of probability theory. Results of both methods are compared, but

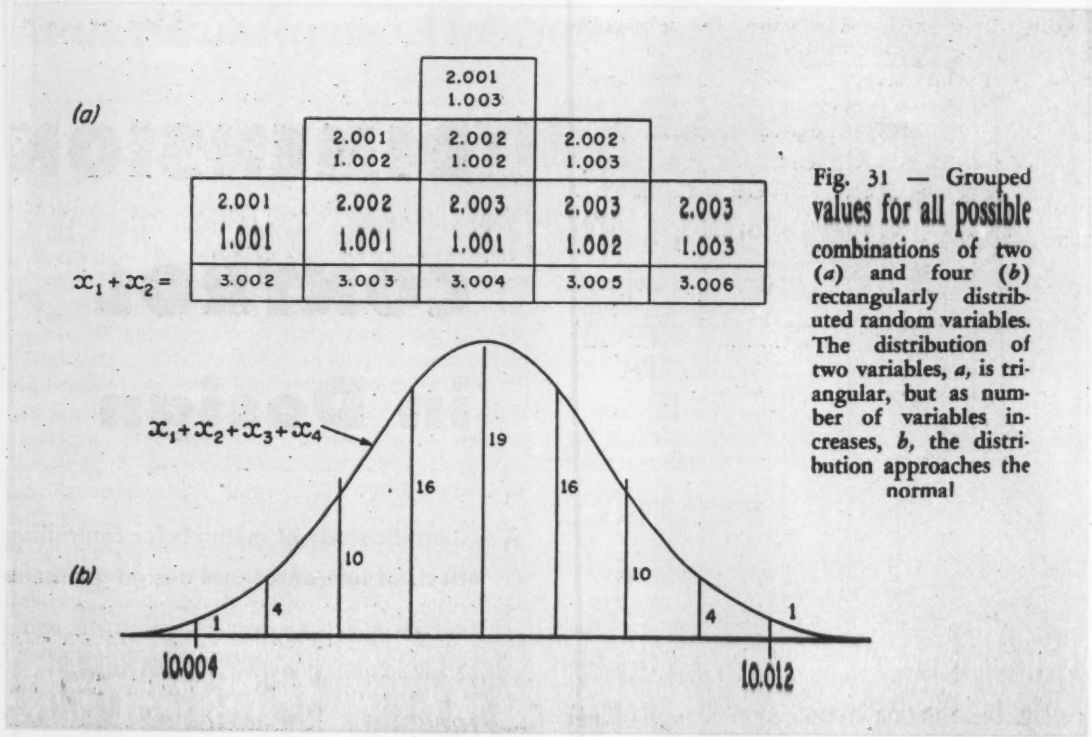


Fig. 31 — Grouped values for all possible combinations of two (*a*) and four (*b*) rectangularly distributed random variables. The distribution of two variables, *a*, is triangular, but as number of variables increases, *b*, the distribution approaches the normal

no attempt is made to indicate when it is, and when it is not, advantageous to use probability methods. A decision will usually embrace a number of considerations pertaining to the design, manufacture and use of a product, not the results of a dimension study only. For this reason, discussion of how and when and why one method should be used instead of another is reserved until Part 7.

Underlying Principles

Application of the laws of probability requires some initial assumptions to be made before the outcome of an event can be predicted. Degree of confidence in a prediction depends on reliability of the initial assumptions. If a problem does not permit an accurate appraisal of the initial assumptions, then the prediction of the outcome of a problem will have a corresponding measure of uncertainty. Consider the three possibilities:

1. The laws that determine the outcome of an event are either unknown, so complicated, or so unpredictable, that no reliable prediction is possible.
2. The outcome of an event may be calculated on the basis of certain simple hypotheses about the phenomena that underlie the problem in question.
3. In spite of the unpredictable behavior of an individual observation, a long sequence of observations may show a remarkable regularity. Thus the prediction of the outcome of the event may then be possible on the strength of the statistical observations.

These three possibilities are illustrated in the following examples.

A person has the choice of taking either a well-paid job, with no apparent opportunity for advancement, or a poorly paid job with many apparent opportunities for advancement. What is the best choice? A calculated decision would depend on the prediction of the outcomes of both choices. But it is apparent that these outcomes are governed by so many complicated and highly unpredictable factors that a reliable prediction is practically impossible. Thus the final decision, when all the facts have been weighed, must be the result of a plausible guess of the outcome of each choice.

Situations abound in mechanical design where it is either impractical or impossible to predict the outcome of an event reliably because the laws that govern the outcome are imperfectly known or unpredictable. In these cases, the usual procedure is to obtain the necessary design information by experimental methods.

Reliability of a prediction also has a lot to do with the grade of tolerances involved. The finer the tolerance, the less reliable the prediction. This is because the effects of temperature, material instability, distortion due to applied loads, etc., become relatively more important, and manufacturing tolerances less important, as the design tolerance becomes smaller.

An example that illustrates how the probability of an event may be deduced from a simple hypothesis has to do with drawing marbles from a box. If a box holds 90 white and 10 red marbles, what is the chance of drawing a white marble? The simple hypothesis is that any marble is as likely to be drawn as any other. This hypothesis is admissible only if the marbles are thoroughly mixed and if the choice is a random one; that is, if it is impossible to know beforehand that the

marble will be either red or white. The probability based on the hypothesis is that the chance of drawing a white marble is 9/10. If the person making the drawing were to look into the box and select a particular marble, then the choice would of course not be random.

Thus, from the simple hypothesis, the question about drawing a marble from the box is easily answered. A more difficult problem, however, would be: What is the probability of drawing a particular combination of marbles, say three white marbles in succession? The answer to this question may again be based on the assumption of equal likelihood—but the rule for arriving at the answer is not so obvious. The theory of probability gives rules from which it is sometimes possible to calculate the outcome of an event. These rules, in common with the rules of other mathematical disciplines, are derived by purely formal reasoning from a set of simple definitions and axioms.

Probability Distributions: Because of the nature of the problem, in the case of the marbles, the solution rests on the probability of a choice being *either* red *or* white. The most fundamental rules for calculating probabilities are concerned with such simple alternatives. Although there are only two alternatives for the marbles, in many instances there are many. In a game of dice, for instance, a die can land any one of six possible ways. Another situation is when the initial conditions must be given in the form of probability distributions—as in the case of dimensions. However, the rules for calculating the probable occurrence of a combination of dimensions, or of drawing three white marbles in a row, are derived from the same fundamental axioms.

The rectangular distribution may be regarded as a form of the assumption of equal likelihood. Thus, when a dimension is assumed to have a rectangular distribution, any value of the dimension between limits is given an equal probability of occurring as any other. A value falling outside the limits has, theoretically, no chance of occurring.

The number of different forms of distributions is virtually unlimited. Some, like the rectangular, are based on simple hypotheses; others on involved, complicated reasoning; and some are found in practice. An important consideration is that a distribution lends itself to reasonably brief calculations. This demand is satisfied if the distribution can be described by a few simple parameters. This is so for both the rectangular and the normal distributions. The significance of the parameters for the normal and rectangular distributions has been covered in Part 1.

The normal distribution commands an important role in probability and statistical theory because so many of the distributions that occur in numerous fields of experience closely approximate the normal. This fact has been explained by arguing that a deviation from an ideal value should be regarded as the sum of a large number of independent elementary deviations. Then, because of the central limit theorem, the resultant deviation should be approximately normally distributed; the central limit theorem asserts that the sum of a large number of independent variables, whatever their distributions, is asymptotically normal. It has been said that the experimenter believes in the normal distribution because he thinks it is a mathematical fact, and the mathematician believes in it because he thinks it is an experimental fact.

Since the advent of statistical control in manufacture, it is possible to assure that a process distribution will be very close to normal. This is done by controlling all nonrandom sources of deviation, such as tool wear in a machining process, so that the process deviations are random. When a process is controlled it is possible to predict the probability of a dimension value falling within specified limits. It is not unreasonable, however, to expect that many distributions will be normal even though the operations are not statistically controlled.

Risk is an important factor in calculations involving normal distributions. A certain amount of common sense should always be used when in-

Nomenclature

C = Cost
F = Function
j = Any individual number
k = Constant
M = Combination of modifiers affecting a particular variation, v (see Part 3)
u = Standardized normal variable (standard deviation of a standardized normal distribution)
v = Variation of a dimension condition
x = Dimension (a variable)
y = Dimension condition, a dimension which results from combining two or more other dimensions
r = Probability-distributed variable
σ = Standard deviation
ϕ = Function relating several independent random variables
χ = Independent random variable
ψ = Dependent variable resulting from a combination of independent random variables

Bar over a symbol (i.e., $\bar{\psi}$) indicates a mean (arithmetic average)

Subscripts

$a, b, \ldots$ = Individual linear dimensions
j = Generalized number representing any individual unit in a group
l = Minimum
n = Number representing the last unit in a group
P = Probability distributed
tr = Of a mechanism train
$1, 2, \ldots$ = Numbers representing individual units in a group

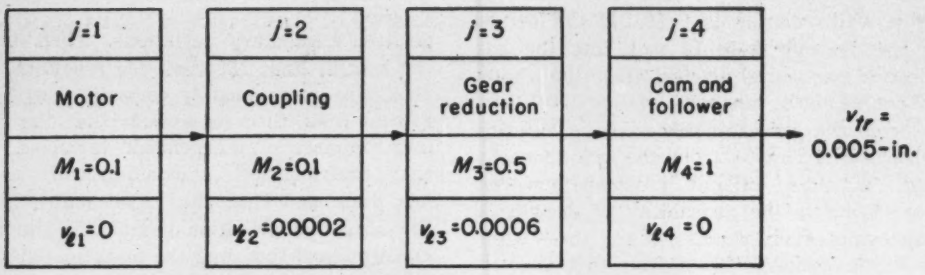


Fig. 32—Schematic of mechanism train used as an example in Part 3

terpreting results. The risk will never be exactly known for, in the first place, a distribution may only approximate the normal; it is hardly likely that it will ever be exactly normal. Furthermore, the values assumed for the process and measurement standard deviations will, in general, never exactly match the values that occur in practice. Whatever values are assumed, they should always be conservative estimates so that the theoretical risk will never be exceeded by the real risk; the combination of dimensions in a relationship, as well as the distribution of individual dimensions, determines what the distribution of the dimension condition will be.

Combinations of Independent Random Variables: Dimension relationships take on special significance when they have probability distributions; dimensions are then random variables.

A dimension is independent when it is not related to the value of any other dimension in the same relationship. For instance, in *Fig.* 29 the slip ring assembly has four similar separator rings. The heights of these rings are part of the dimension relationship that controls the space for the bowed retaining ring. If the rings are manufactured in such a way that the measurement of the height of each ring varies within the range of the dimension limits, and these heights exhibit no tendency to cluster about the same value, then the dimensions are probably independent. This could be the case, for instance, if each ring were machined separately. On the other hand, suppose that each ring is molded in the same die so that the height of the rings tend to group around the same measurement as shown in *Fig.* 30; in such a case, the dimensions are probably not independent.

Table 5—Evenly Spaced Values of Four Rectangularly Distributed Variables

χ_1	χ_2	χ_3	χ_4
1.001	2.001	3.001	4.001
1.002	2.002	3.002	4.002
1.003	2.003	3.003	4.003

Before dealing specifically with dimension relationships, random variables in general will be discussed.

If a combination of independent random variables is some function,

$$\psi = \phi\ (\chi_1, \chi_2, \ldots, \chi_n) \quad \ldots\ldots (13a)$$

and, furthermore, if the function is approximately linear for the range of variation of ψ, then the following relationship holds true:

$$\sigma^2 = \left(\frac{\partial \phi}{\partial \chi_1}\right)^2 \sigma_1^2 + \left(\frac{\partial \phi}{\partial \chi_2}\right)^2 \sigma_2^2 + \ldots + \left(\frac{\partial \phi}{\partial \chi_n}\right)^2 \sigma_n^2 \quad \ldots\ldots (13b)$$

where σ is the standard deviation of ψ, σ_1 of χ_1, etc. Also, the mean of the function is equal to to the function of the means:

$$\bar{\psi} = \phi\ (\bar{\chi}_1, \bar{\chi}_2, \ldots, \bar{\chi}_n) \quad \ldots\ldots (13c)$$

Two special cases are particularly important. The first is when the function has the form

$$\psi = k_1 \chi_1 + k_2 \chi_2 + \ldots + k_n \chi_n \quad \ldots\ldots (14a)$$

where the k's are constants. For this case Equation 13*b* reduces to

$$\sigma^2 = k_1^2 \sigma_1^2 + k_2^2 \sigma_2^2 + \ldots + k_n^2 \sigma_n^2 \quad \ldots\ldots (14b)$$

and the mean of the function,

$$\bar{\psi} = k_1 \bar{\chi}_1 + k_2 \bar{\chi}_2 + \ldots + k_n \bar{\chi}_n \quad \ldots\ldots (14c)$$

The other special case is when

$$\psi = \chi_1 + \chi_2 + \ldots + \chi_n \quad \ldots\ldots (15a)$$

so that

$$\sigma^2 = \sigma_1^2 + \sigma_2^2 + \ldots + \sigma_n^2 \quad \ldots\ldots (15b)$$

and

$$\bar{\chi} = \bar{\chi}_1 + \bar{\chi}_2 + \ldots + \bar{\chi}_n \quad \ldots\ldots (15c)$$

From Equation 13*b* (or the special cases 14*b* and 15*b* when they are applicable) equations of variation are derived for trains of mechanisms and simple dimension systems.

When the random variables χ_1, χ_2 . . . have normal distributions, then ψ will also be normally distributed. But what if the random variables have rectangular distributions? What then is the distribution of ψ? It is difficult to show by a purely mathematical discussion how rectangularly distributed variables combine, but it can be very simply and effectively demonstrated. Evenly spaced values of four rectagularly distributed variables are given in *Table* 5. The distribution of the sum $\chi_1 + \chi_2$ is obtained by first forming all of the possible combinations 1.001 + 2.001, 1.001 +2.002, etc., and then grouping the combinations having the same totals. This is done in *Fig.* 31*a*; the sum of two rectangularly distributed variables has a triangular distribution.

The distribution of the sum $\chi_1 + \chi_2 + \chi_3 + \chi_4$, obtained in the same way, is shown in *Fig.* 31*b*. The distribution of the sum is in remarkable agreement with a normal distribution; this is actually a demonstration of the central limit theorem. The conclusion that may be drawn from this discussion is that a function of rectangularly distributed variables can, under certain circumstances, be considered as a distribution that is approximately normal.

Variations in Mechanism Trains

The basic approach to the formulation of equations of train variation is given in Part 3 of this series. Briefly, this method includes the development of a general equation and evaluation of the modifiers of the equation for a particular train. The assumption behind the development of the general equation in Part 3 (Equation 5) is that variation is an absolute value; the general equation is an expression of how these absolute values are combined. But what if the variations have probability distributions? How then are the mechanism variations combined so as to yield a useful equation of train variation? This question is answered further on by applying some of the underlying principles already given.

For the purpose of making a comparison, the mechanism train used to illustrate the methods of Part 3 is also used to illustrate the probability methods of this part. Again, as in Part 3, the end results depend on the techniques used for solving equations of train variation.

Equations of Train Variation: In Part 3, variation is simply defined as an absolute value, the difference between the extremes of a dimension condition. In this article, variation is recognized as having two components: (1) an absolute value corresponding to the condition of minimum clearance, and (2) a variable quantity described by a probability distribution. Thus the equation of train variation is the sum of a function of the minimum variations F_l, and a function of the variations associated with the probability-distributed variables F_P; that is,

$$v_{tr} = F_l + F_P \quad \ldots\ldots (16)$$

Because the minimum variations are the same kind of variations dealt with in Part 3, the function F_l is merely a modified form of Equation 5:

$$F_l = M_1 v_{l1} + M_2 v_{l2} + \ldots + M_j v_{lj} + \ldots + v_{ln} \quad \ldots (17)$$

The other component of train variation F_P is derived somewhat differently. To begin with, however, the combination of probability-distributed variables (ν_j) is formed in the same way as the absolute variations (v_j) are:

$$\nu = M_1 \nu_1 + M_2 \nu_2 + \ldots + \nu_n$$

This function has the same form as Equation 14*a*; therefore, because of Equation 14*b*,

$$\sigma^2 = M_1^2 \sigma_1^2 + M_2^2 \sigma_2^2 + \ldots + \sigma_n^2$$

If the ν's are normally distributed (the as-

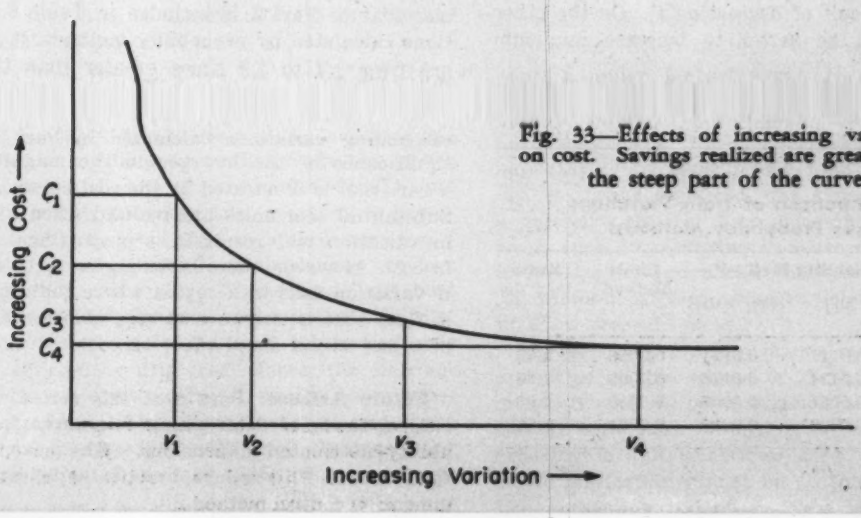


Fig. 33—Effects of increasing variation on cost. Savings realized are greatest on the steep part of the curve

sumption that is followed, although of course it is not the only permissible one) then the relationship between variation and standard deviation for v_j, say, is

$$v_{Pj} = 2 u \sigma_j$$

By combining this and the previous equation, the result is

$$F_P^2 = M_1^2 v_{P1}^2 + M_2^2 v_{P2}^2 + \ldots + M_j^2 v_{Pj}^2 + \ldots + v_{Pn}^2 \quad (18)$$

Although the standardized normal variable, u, does not appear in the equation, it is nevertheless still an important factor in the calculation of train variation; the significance of u in setting the theoretical level of risk is considered further in the discussion of simple dimension systems, Part 6.

In summary, three equations are needed to formulate train variation: Equations 16, 17 and 18. The derivation of the coefficients M in Equations 17 and 18 is fully explained in Part 3.

Solving Equations of Train Variation: The simultaneous solution of equations of train variation for unknown values of both v_l and v_P terms offers some difficulty; it will therefore be avoided. Reasonably good estimates can usually be made of what minimum clearances are satisfactory. From these estimates the minimum variations can be calculated and F_l evaluated. The following equation may then be solved for values of v_P:

$$(v_{tr} - F_l)^2 = M_1^2 v_{P1}^2 + M_2 v_{P2}^2 + \ldots + M_j^2 v_{Pj}^2 + \ldots + v_{Pn}^2 \quad (19)$$

If, after solving this equation, the values of v_P obtained do not prove satisfactory, then it will be necessary to assume new minimum clearance values, and re-solve the equation.

A value of v_P may not prove satisfactory if it is either too small or too large in comparison with the corresponding value of v_l for the same mechanism. When v_P is too small, it means that the tolerances that control v_P may be profitably increased as a result of decreasing v_l. On the other hand, it might be better to increase minimum clearances, at the expense of tightening up on tolerances, if it is better to have easier assembly conditions.

Again, as in Part 3, the way in which the solution of an equation of train variation is carried through, and the results obtained, depends on the nature of an initial assumption. Not just one, but a whole family of solutions can be obtained from Equation 19, depending on the assumptions chosen. Inasmuch as an assumption is an arbitrary thing, the basis for a sensible choice should rest on a comparison of results.

Consider the assumption, corresponding roughly to the square-root assumption of Part 3.

$$M_1 v_{P1}^2 = M_2 v_{P2}^2 = \ldots = M_j v_{Pj}^2 = \ldots = v_{Pn}^2$$

or

$$v_{Pj} = \frac{v_{Pn}}{\sqrt{M_j}} \quad (20)$$

Combining this and Equation 19 gives

$$(v_{tr} - F_l)^2 = v_{Pn} (M_1 + M_2 + \ldots + M_j + \ldots + M_{n-1} + 1) \quad (21)$$

which may be readily solved for v_{Pn}. By means of Equation 20 the remaining v_P values may be obtained.

Equations 20 and 21 are valid only if all values of v_P are unknown; if this is not so, then modified forms of the equations will have to be derived.

By applying the above results, another set of values for the mechanism train of *Fig.* 20 (Part 3) has been calculated. The computation is based on estimates of minimum clearances, and on the coefficients, M, evaluated in Part 3. Pertinent data are summarized in *Fig.* 32. Note that only two of the four mechanisms have minimum variations: the coupling and the gear. Not all mechanisms have minimum variation. Indeed, one of the requirements for accuracy in many types of fine instruments is that all erratic sources of variation, and therefore conditions of minimum clearance, be eliminated.

A comparison of the results of this analysis and that of Part 3 is included in *Table* 6. Variations calculated by probability methods, it is seen, are from 1.7 to 1.9 times greater than the corresponding variations calculated in Part 3. The significance of the increase in the magnitude of a variation is illustrated by the cost curve, *Fig.* 33. Substantial economies are realized when a change in variation will result in a proportional change in cost. However, there is little gain to be realized if variation falls in a region where the cost curve is flat; that is, where a change in the magnitude of v has only a small effect on cost.

Future Articles: Part 6 of this series will discuss methods of determining tolerances for probability-distributed dimensions. The seventh and final article will discuss practical applications of dimension control methods.

Table 6—Comparison of Train Variations (Limit versus Probability Methods)

j	Units	Probability Method* v_{lj}	v_{Pj}	$(v_{lj} + v_{Pj})$	Limit Method† v_j	Ratio $\frac{v_{lj} + v_{Pj}}{v_j}$
1	radian	0	0.0114	0.0114	0.0066	1.73
2	radian	0.0002	0.0114	0.0116	0.0060	1.76
3	radian	0.0006	0.0051	0.0057	0.0030	1.90
4	radian	0	0.0036	0.0036	0.0021	1.71

*Part 5. †Part 3.

Factors affecting

Oil-Groove Design in Bearings

Unidirectional and rotating loads

Oil flow requirements

Permissible bearing loads

Position of oil inlet

Axial versus circumferential grooving

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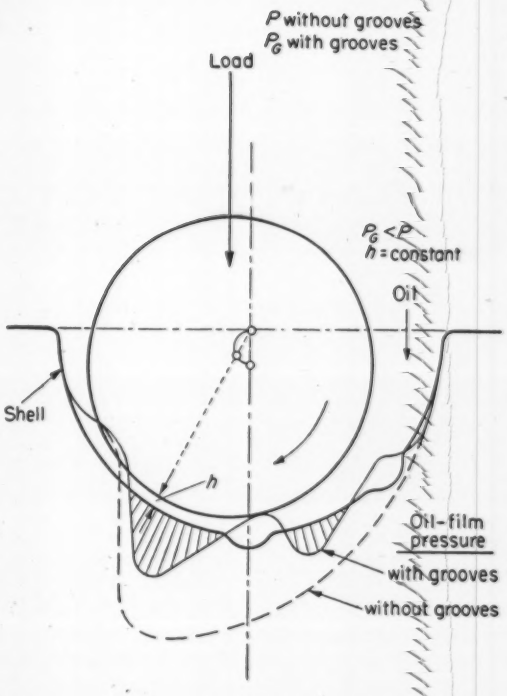

Fig. 1—Side view of bearing with axial grooves. Comparison of effects on oil-film pressure of a bearing with and without axial oil grooves are depicted

A BEARING whose axial length is about equal to or shorter than its diameter generally represents a good modern design. The trend toward shorter bearings, versus the obsolete practice of making them considerably longer than wide, began when designers learned that journals flex under higher loads and tend to overload the edges of the bearing. This action causes increased nonfluid friction at the bearing edges, resulting in the eventual destruction of the lining. Also, long bearings are inherently more difficult to lubricate because the distribution of the lubricant often presents a problem. Many a weird grooving system originated because of the obsolete practice of designing journals too thin and bearings too long. With a pressure lubricating system, both oil feed and oil distribution in the bearing are basically minor problems.

Overgrooving: In the first place, overgrooving originated at a time prior to the recognition of the hydrodynamic theory of lubrication (1883) and certainly before its entry into practical engineering. Secondly, long bearings with their larger surface area appeared safer than short ones because, logically, they could carry higher loads and hold more oil, provided the shaft did not flex. Thirdly, rotational speeds were low and lubrication was usually effected by drip feed. Hence, the distribution of the oil over the length of the bearing became a problem. Also, since bearings used to be fitted, that is, provided with "no" clearance, the natural solution of the lubrication problem seemed to be to provide oil channels. Frequently the odd looking groove patterns were based upon experience and, in view of an erroneous theory of lubrication, may often have been an improvement in the cases for which they were designed.

However, fitted or blued-in bearings can never operate under hydrodynamic conditions anyway until they have "freed" themselves more or less haphazardly by considerable wear. Hence, grooving, as it was practiced, was generally considered a necessity. By the time a clearance develops by wear, such overgrooving becomes a nuisance since it impairs hydrodynamic lubrication by connecting would-be high-oil-pressure, load-carrying areas with low-pressure areas.

The grooving problem hinges mainly on an appreciation of the concept of the hydrodynamic lubrication with its predetermined bearing clearance and an automatic oil-feeding system. Criss-cross grooving is still sometimes used where hydrodynamic lubrication cannot be accomplished anyway. The connecting rod of a steam locomotive is an

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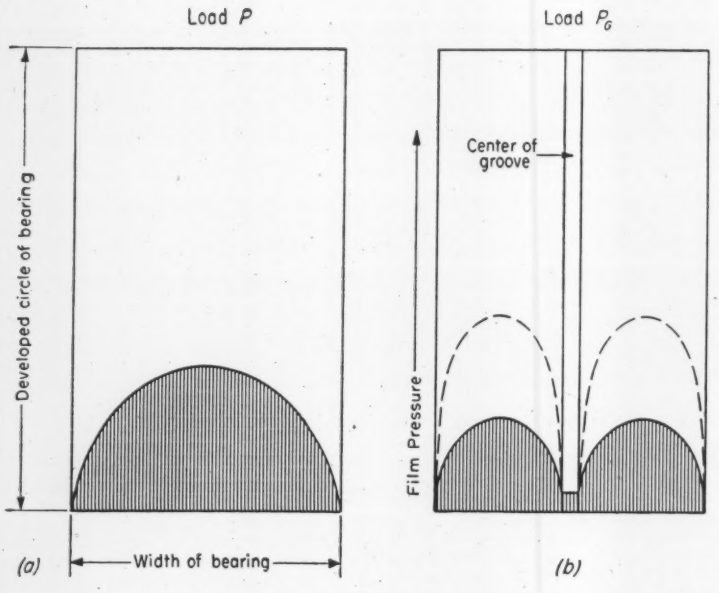

Fig. 2—Developed view of bearing showing effects of no grooving, *a*, and a circumferential oil groove, *b*, on load-carrying capacity. High-pressure area for same minimum oil-film thickness *b* is shaded; in this case, $P_G < P$. Broken-line curves in *b* indicate high-pressure area for $P_G = P$ and decreased oil-film thickness, $b_G < b$

example. The soundness of this practice is disputed.[1]

Modern Practice: From the acceptance of the hydrodynamic theory there followed the basic principle of modern grooving, namely: let the hydrodynamic pumping action of the system that creates the load-carrying pressure in the oil film take care of itself and avoid any grooves in the bearing that connect areas of high pressure with areas of low pressure. The load that can be carried if the same safe oil-film thickness is maintained with and without axial grooving is illustrated in Fig. 1. The effects of a circumferential groove in a bearing are depicted in Fig. 2 in a developed view.

The ideal bearing would be a smooth tube in which the shaft rotates with a certain oil-filled clearance; such a bearing would pump the oil under the journal and thus lift it. Thus, a small section of the circumference of the gearing developed in Fig. 2 is subjected to a high oil pressure whereas a larger area is under much lower pressure. Any complete annular groove will connect these sections and will act locally as an enormously increased clearance and as a channel which tends to equalize the pressure to the detriment of the load-carrying capacity, as demonstrated in Figs. 1 and 2.

There are two effects of a circumferential groove impairing load-carrying capacity: (1) the greater "channel" effect and (2) the smaller "clearance" effect.

Partial Annular Grooves: An incomplete or partial annular groove properly placed, that is, in a low-pressure area, need not produce a significant channel effect; this may be said for any grooving system placed in an unloaded area. Such grooving is sometimes provided in unidirectionally loaded bearings, where it is readily applicable, in order to increase the flow of oil either as a cooling medium or simply to make more oil available.

Axial Grooves: Grooving for increased oil flow usually has the form of axial grooves, which are typically used for oil distribution. The basic principles of grooving are the same as discussed previously. More specifically, such an axial groove should never go through the whole length of the bearing because it would connect high-pressure regions with regions of zero pressure, particularly with a rotating load. This factor is important in connection with any axial oil-distributing grooves. In a bearing about 2 in. long such a groove should end about ¼-in. from either end of the bearing.

The groove should not have sharp edges; the transition from the groove to the surface of the bearing should be smooth and gradual to avoid an oil-scraping action. This is particularly true at the edge of the groove across which the oil feeds to the high-pressure area. Axial grooves do develop a certain "channel" effect when the load is rotating because, at times, they do connect areas of high and low film pressure. This effect as well as the "clearance" effect is mostly outweighed by the groove functions of oil storage and supply.

Circumferential Grooves: An injudicious application of a grooving idea is illustrated in Fig. 3 by the circumferential side grooves in a connecting-rod bearing of a special internal-combustion engine. The side grooves were derived from so-called collector grooves. Such grooves served to

[1]References are tabulated at end of article.

collect the side leakage primarily in stationary, unidirectionally loaded bearings to prevent oil splash. This is possible only when a drain hole at the bottom is provided. There was no such hole in this case; thus, at best all three grooves were intended as oil-storage grooves. The central groove registered with the oil hole in the crankpin and may have served as an oil-storage and distribution groove without impairing the service of the whole machine element.

This bearing becomes, through separation by the central groove, a twin bearing. Its load capacity for the same minimum oil-film thickness is smaller than the load capacity of an ungrooved bearing because of the side leakage to oil pump pressure in the groove, as well as side leakage to atmospheric pressure. This phenomenon is illustrated in Fig. 2. If this fact is considered in the dimensional design of the bearing, and space is available for a twin bearing, the design is sound, notably with larger bearings. It is preferable to an axial groove, which would tend to make the oil film unstable when swept by a rotating load. As a rule, connecting-rod bearings of passenger-car engines are not grooved at all. Obviously, natural oil distribution is easier with such small and short bearings.

Oil Flow: There is an apparent paradox to the central circumferential groove. As discussed previously, the lubricating oil serves a dual purpose—lubrication and cooling. Of course, grooving is one means to that end. However, most of the heat evolved in the bearings, such as used in a majority of modern internal combustion engines, is carried away by the oil. The flow of this oil increases as the cube of bearing clearance.

It is frequently stated that bearing clearance controls the quantity of oil flow through a bearing, and no mention of grooving is made. Experimental evidence[2] shows that a circumferential groove increases the flow of oil materially. This apparent paradox may be explained as follows.

If the journal runs concentric with the bearing, a central circumferential groove should not affect oil flow if the temperature is constant. This is true because the distance from the journal to the bearing is everywhere the same and so is the resistance to the oil flow. Actually, the journal rotates with a certain eccentricity. Hence, the oil flows not through an annular but a more nearly crescent-shaped space. The resistance to flow in such a space is not uniform and is greatest where the journal is close to the bearing. By cutting a groove into the bearing, a greater eccentricity of the journal is developed. The journal comes closer to the bearing in the high-pressure area and correspondingly recedes away in the low-pressure area. Thus, without increasing the design clearance, the running clearance is decreased in one place and increased in another which permits more oil to flow through the region of least resistance. This increased oil flow results in better cooling and higher operating oil viscosity, which may well compensate for the loss of load-carrying capacity caused by the groove.

This eccentricity effect also explains why oil flow varies with rotational speed of the journal. This variation is difficult to predict quantitatively since more heat will be generated at higher speeds, and

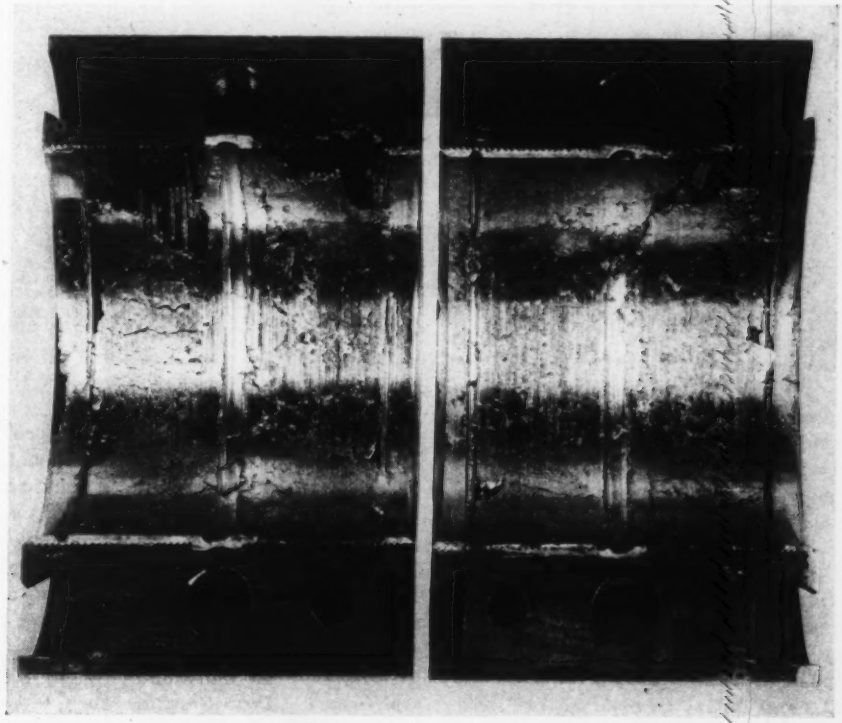

Fig. 3—Bearing with three circumferential grooves (both halves shown). Failure occurred primarily because of inadequate clearance and poor bond of babbitt metal to the steel

the oil viscosity will drop while the eccentricity tends to decrease.

Oil-Hole Location: Another item to consider is the introduction of oil, such as from a crankpin into the bearing. Where is the best place to locate the oil hole?

There are two schools of thought in this regard. Usually, only a general and basic principle is given, namely, to introduce the oil into the low-pressure area of the bearing. This is an unassailable principle. Unfortunately, it is readily applicable only to stationary bearings with a unidirectional load. Crankpins do not belong in that category.

Accordingly, one procedure is to determine the load diagram of an engine, for example, and thus find the best position of the oil hole in the crankpin. This is a very tedious method.

According to another school of thought, the oil hole should be at the outermost point on the crankpin, regardless of the shape of the load diagram, in order to take advantage of the centrifugal force that acts to increase the effective feed pressure to the bearing.

In view of the scarcity of specific discussions on the subject with regard to rotating loads, a statement by Clayton[3] may be of interest to the designer. Clayton investigated grooving, oil flow and position of oil holes, and stated, "As in the aero engine, particularly the radial engine with large master rod, the centrifugal forces are high at high speed, there is in such cases substantially unidirectional loading, the point of application (of the load) being on the inside of the crankpin." This statement, too, implies the acceptability of the oil hole at the outermost point of the crankpin. It is the usual location of the oil hole in passenger-car engines. For a different arrangement, where the oil hole leads the top-center position of the crankpin by approximately 60 degrees, see Reference 4.

It might be argued that with a rotating load the oil hole in the shaft will always sweep unloaded or low-loaded zones at times. From this point of view the exact position of the hole seems rather irrelevant, although the question of its best position is not affected by this consideration.

This somewhat primitive reasoning is perfectly correct when the oil hole registers with a circumferential groove which amounts to an enormously increased clearance or a circumferential low-pressure area as stated before. Obviously, it would be misunderstood accuracy first to determine with meticulous care the best location of the hole in the area of lowest pressure and subsequently to make the effort illusory by cutting a groove which extends the low-pressure area over the whole circumference of the bearing.

In this connection it should be emphasized that the groove must be exactly centrally located, or else the bearing and crankpin will not run coaxially. The bearing or bushing should be slightly bellmouthed at the ends to obviate destructive edge-loading.

Evaluation of Conflicting Statements: The student of actual designs and of the original literature on bearing design and performance is sooner or later bound to come across flagrant violations of the simplest and most basic principles of design of clearances, grooving, oil holes, etc. Sometimes, however, these design deviations are justified and necessary.

For example, the most familiar case is the central circumferential groove in the main bearings of automobile-engine crankshafts. This groove is not necessary for the main bearing itself, which it splits in two, but for feeding oil into the adjacent crankpin. The main bearing has to be so dimensioned that it carries the load despite the partition.

Examples of odd grooving are shown in References 5 and 6. In Reference 5 is also shown an example of a noncircular bearing. These examples refer to very special cases of unidirectionally loaded bearings and are explained by the authors. Such explanations are not always given.

An example of conflicting statements regarding the influence of a circumferential groove on oil flow is presented in References 2 and 5. In Reference 2 the claim is made that a circumferential grove will increase oil flow 100 per cent whereas Reference 5 says, "The oil flow is not increased appreciably." The only conclusion to be drawn for lack of detailed knowledge is that some other undisclosed condition was different in the two cases.

The general conclusion, whenever some rather unconventional design is encountered, is to look for the reasons and conditions of its application, and then compare these very carefully with the case at hand. The first item to check is whether the design refers to a unidirectional or a rotating load. Most written information on bearings deals only with unidirectional loading.

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"To be as effective as he should be, the engineer of today and tomorrow should be a leader, not a problem, in the matter of getting along with people. Knowing and using the laws of human relations is just as important to his progress as his ability to get physical materials and the laws of nature to work for him, not against him. It will help him gain faster recognition and go ahead further and more easily—both as an engineer and an individual." W. C. NEWBERG, *president, Dodge Div., Chrysler Corp.*

Designing for

Soldered Joints

Alloys and Fluxes
The Soldering Process
Joint Strength
Solderability of Metals

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SOFT SOLDERING joins metals with low-melting alloys in a working temperature range of 200 to 700 F. The metals joined are high-melting, strong metals compared to the low-melting, weaker alloys used for soldering. Solder is generally used to obtain a smooth joint or to assure complete metallic contact between mating or component metals. It is employed for sealing, electrical contact or joining where the joint will not be subjected to excessive stress, vibration, temperature or corrosion.

When all conditions are favorable, a drop of molten solder flows neatly into a fluxed joint. The ease with which this takes place accounts for the popularity of this joining method. On the other hand an attempt to solder a joint when conditions are not right can be a highly exasperating experience.

The requirements for successful soldering are relatively simple. The solder must be capable of alloying with the metal to be soldered. This is a surface or contact alloying that accounts for the wetting and spreading properties of the solder. The other basic requirement is that the surface be clean at the soldering temperature at the instant that the solder flows over the surface. This clean condition at the instant of soldering is promoted by the action of the flux. Although the basic requirements are simple, a great many minor factors can contribute to success or failure.

Alloys: Lead-tin alloys are used in most applications for soft soldering. Alloys containing 2 to 100 per cent tin can be used although the extremes in composition are seldom applied.

The melting range for a solder is important, since both underheating and overheating lead to trouble. Also, wiping solders are molded within the melting range. The melting range diagram for

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Table 1—Lead-Tin Solders

Alloy Grade	Lead Nominal (%)	Tin Desired (%)	Antimony Min. (%)	Antimony Max. (%)
5 A	5	95	..	0.12
10 B	10	90	..	0.50
20 C	20	79	0.8	1.2
25 A	25	75	..	0.25
30 C	30	68.4	1.4	1.8
35 A	35	65	..	0.25
40 B	40	60	..	0.50
50 B	50	50	..	0.50
60 A	60	40	..	0.12
70 B	70	30	..	0.50

From ASTM Standard Specification B32-49.

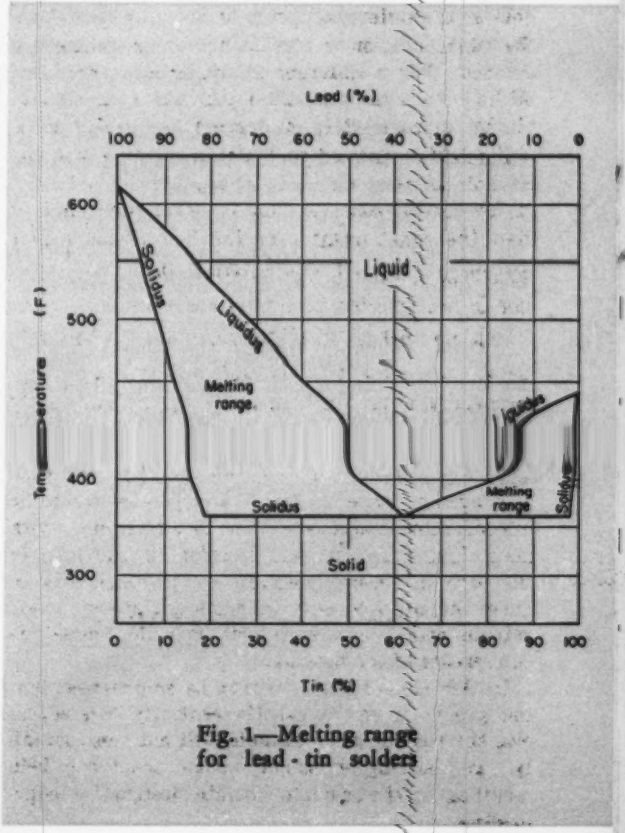


Fig. 1—Melting range for lead-tin solders

the lead-tin alloys is shown in *Fig.* 1. The *solidus* temperature is the temperature at which melting begins and the *liquidus* temperature is the temperature at which melting is complete. Between these two temperatures the alloy consists of a slush of solid and liquid. The higher the temperature, within this range, the more liquid present in the slush.

For good soldering practice the soldering temperatures would be 25 to 100 F above the liquidus temperatures, that is, within the range shown in *Fig.* 2.

For reproducible results it is advisable to standardize on a particular alloy. The lead-tin alloys can be purchased to Federal, SAE, ASTM or commercial specifications to assure consistent melting characteristics and physical properties.

Several lead-tin solders are listed in *Table* 1. Antimony is an impurity that increases the strength but lowers the ductility of the lead-tin alloys. For good ductility the maximum antimony content is kept low. If some increase in strength is desired a higher antimony content and a range are specified. The presence of other metals lowers the melting point of the alloys, but for small amounts this is an insignificant factor.

For many years the 50-50 alloy was used as a general-purpose solder. This solder has a liquidus temperature of 420 F and contains a high amount of tin, so that wetting and spreading are good.

For solders that are to be molded, as for wiped joints, alloys containing 30 to 35 per cent tin have been preferred, to take advantage of working within a broad melting range.

Alloys low in tin should be given every consideration because of the scarcity and consequent high price of tin. Such alloys require a higher soldering temperature and do not spread and wet as readily as those containing larger amounts of tin. However soldering characteristics are good for alloys containing 20 to 25 per cent tin.

For a low-melting and quick-setting alloy the eutectic (minimum liquidus temperature) composition of 38 lead, 62 tin is desirable.

High-tin alloys and even pure tin are useful for corrosion resistance. Pure tin, for example, is used for joining tin-coated distilled water lines.

Special Solders: During the war lead-silver solders containing 1.5 to 2.5 per cent silver were developed because of the tin shortage. The silver-lead eutectic containing 2.5 per cent silver has good fluidity, good spreading, and a melting range of 580 to 585 F.

Low-melting solders, made by the addition of bismuth, are used principally for soldering low-melting alloys such as pewter. A few typical compositions are shown in *Table* 2.

Tin can be strengthened by the addition of antimony to produce a high-strength, lead-free alloy. The 95 tin, 5 antimony alloy has a small melting range in the vicinity of 450 F.

For joints required to withstand higher temperatures than the lead-tin alloys permit, a solder consisting of 95 per cent cadmium and 5 per cent silver can be used. This alloy has a melting range of 640 to 740 F.

The eutectic cadmium-zinc alloy containing 82.5 per cent cadmium and 17.5 per cent zinc is recommended for soldering zinc-base die castings. This alloy melts at 508 F.

Perhaps it is well to mention that molten cadmium in large volumes or at high temperatures gives off toxic fumes. Also cadmium is highly toxic in foodstuffs and should not be used for containers for handling or processing foods.

An alloy containing 60 per cent tin and 40 per cent zinc, also various proprietary alloys, are available for soldering high-purity aluminum or wrought aluminum alloys containing not over one per cent manganese or magnesium.

Forms of Solder: Soft solders are commercially available as bars, sticks, wire, sheet or ribbon, segments, drops and powder. Rosin-core wire and acid-core wire are available. Dry mixtures of powdered alloy and flux and pastes containing fluxes

Table 2—Low-melting Solders

Nominal Composition — Lead (%)	Tin (%)	Bismuth (%)	Liquidus Temperature (F)
25	25	50	266
50	37.5	12.5	374
25	50	25	338

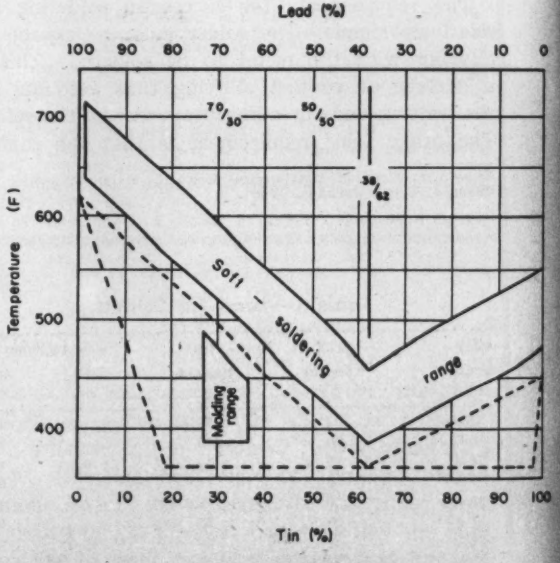


Fig. 2—Soldering and molding ranges for lead-tin solders

and solder can be obtained.

Fluxes: Zinc chloride, and mixtures of zinc chloride and ammonium chloride, remove thin oxide films from many metals rapidly at soldering temperatures. The fluxing action is a high-temperature pickling to expose clean metal to the alloying between the solder and the metal. These corrosive acid fluxes are quick-acting and promote good wetting. They may be utilized as powders, pastes or solutions. The residue remaining after soldering is corrosive and should be cleaned from the surface. This is best done by washing or by neutralizing in a dilute alkaline solution followed by rinsing in water.

Where it is difficult to clean after soldering, rosin is used as a noncorrosive flux. A convenient paste for this flux consists of powdered rosin mixed into petrolatum.

Levulinic acid in alcohol is used for soldering terne plate and tin plate for the manufacture of metal cans and containers.

Soldering Process: Metal that is to be soldered

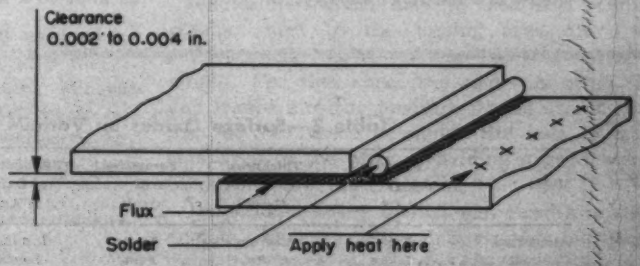


Fig. 3—Placement of solder and where to apply heat for a plain lap joint

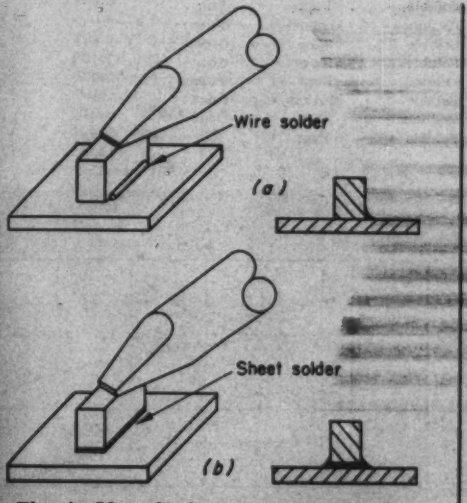


Fig. 4—Use of a heat source remote from the area to be soldered. Wire solder may not penetrate joint if fit is too close, *a*

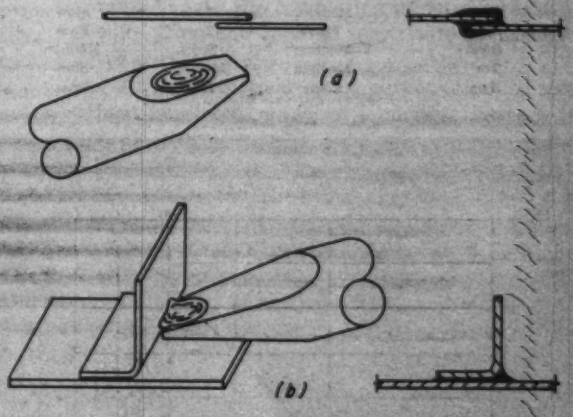


Fig. 5—Use of a drop of hot solder as a heat source in joining wires, *a*, and sheet metal, *b*. In *b* the iron is used to flow and iron the solder into a joint

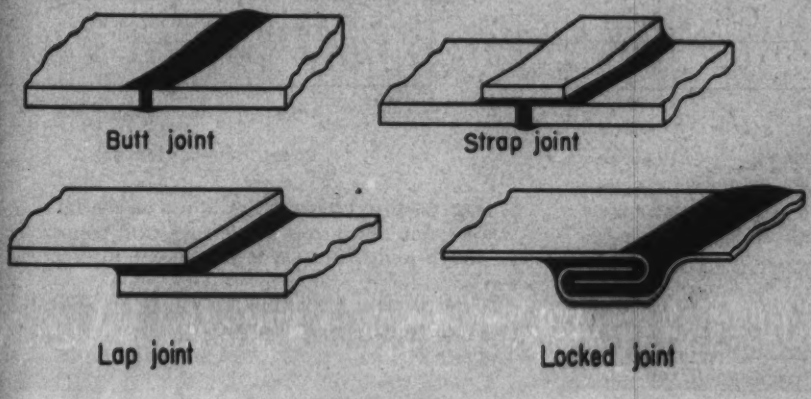


Fig. 6—Various types of soldered joints. Lap, strap and locked joints provide greater soldered area than butt

should be cleaned of all dirt and grease. Any heavy scale or oxide must be removed by mechanical means, such as filing, sanding or scratching. The oxides that can be removed by the flux are thin invisible oxides or at most only a discoloration on the surface. For these oxides that are normally present, *Table* 3 lists the factors that account for the relative solderability of various metals. Aluminum is difficult to solder because the tight, insoluble oxide film is difficult to remove. After the film is removed a highly active metal is exposed. Soldering is satisfactory for copper, nickel, silver and steel where the film is readily removed by the flux and the metal exposed is active, but not too active.

The soft solders are used principally for joining steel, copper, brass, bronze, nickel and Monel. For these metals the lead-tin solders are used and the procedure consists of cleaning, fluxing, heating and applying the solder. Cleaning can be done with alkaline cleaners or organic solvents and by wiping with a dry cloth, if the surface is not too dirty. If the joint is merely for an electric contact, cleaning is not so important. For sealing, good cleaning of the entire surface to be soldered is essential to avoid leaks.

Temperature is important even though it is often not measured. Overheating should be avoided, since this will cause oxidation of the metal, oxidation of the solder, buckling and discoloration of the work. These troubles can often be kept to a minimum by applying the heat a short

Table 3—Surface Oxides on Various Metals

Metal	Tenacity of Oil	Thickness of Oxide	Formation of Oxide	Solubility of Oxide in Acid	Reactivity of Metal	Solderability of Metal
Aluminum	Tight	Medium	Fast	Insoluble	Rapid	Poor
Cadmium	Loose	Thick	Fast	Soluble	Fast	Fair
Copper	Medium	Medium	Slow	Soluble	Slow	Good
Lead	Tight	Thin	Fast	Soluble	Slow	Fair
Magnesium	Medium	Thick	Fast	Soluble	Fast	Fair
Monel	Tight	Thin	Medium	Medium	Medium	Fair
Nickel	Tight	Thin	Slow	Soluble	Slow	Good
Silver	Medium	Thin	Slow	Soluble	Slow	Good
Stainless	Tight	Thin	Fast	Slow	Slow	Poor
Steel	Medium	Thick	Medium	Soluble	Medium	Good
Tin	Medium	Medium	Slow	Medium	Slow	Good
Zinc	Loose	Thick	Fast	Soluble	Fast	Fair

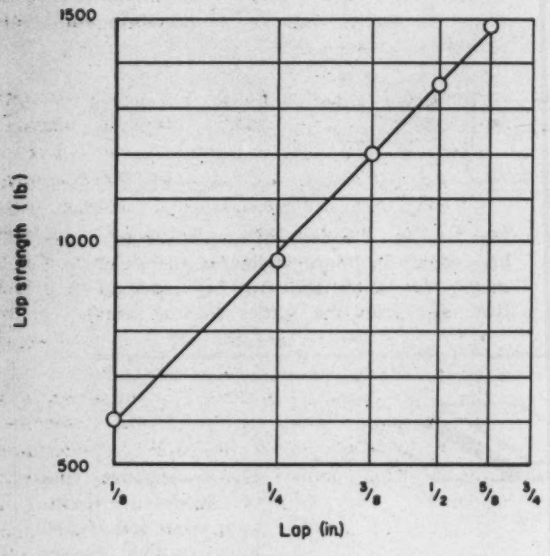


Fig. 7—Strength of lapped soldered joints, 1 inch wide

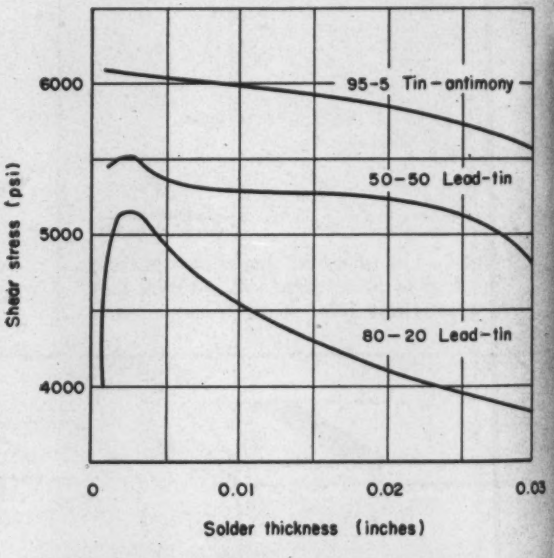


Fig. 8—Effect of solder thickness on strength of joint. Two top curves are for copper sleeve joints. Bottom is for brass lap joint†

†*National Bureau of Standards Circular* 492, April 28, 1950, U. S. Government Printing Office, Washington 25, D. C. (Includes a bibliography.)

distance from the joint and allowing the joint to come to the proper temperature by conduction.

Conditions for soldering a lap joint are shown in *Fig.* 3. The two pieces to be jointed are cleaned and the facing areas are covered with a thin layer of flux. The pieces are clamped rigidly in place with a clearance of 0.002 to 0.004-inch. The solder is then laid close to the joint. Heat flows to the joint; the solder melts and flows readily between the two pieces. After the solder completely fills the space between the two pieces, heating is stopped and the joint is allowed to cool until the solder solidifies. If the joint is broken, examination of the fracture will reveal the extent of coverage. Complete coverage indicates proper cleaning, fluxing and heating.

A soldering iron or a torch can be used as a source of heat. For small areas or thin metal the heat from an iron is easy to control. Where the section is massive, a gas-air, acetylene-air or gasoline blow torch flame will be necessary to bring the temperature of the joint above the liquidus temperature. Where parts can be cleaned, fluxed, and assembled with the solder in place, induction heating is used for high-production methods.

The use of an iron for heating remote from the joint is shown in *Fig.* 4. Illustrated in cross section is the result of using this method with too good a fit. The solder remains on one side and the resulting bond is weak and only useful for tacking, *Fig.* 4*a*. This can be overcome by pre-soldering one piece or by the use of a sheet of solder, *Fig.* 4*b*.

The molten solder may be used as a medium to conduct heat to the joining area. A drop of solder touched to wires, *Fig.* 5*a*, is a common example. For thin sheet the solder is often flowed and ironed into the juncture by the use of an iron, *Fig.* 5*b*. In these examples the iron is massive compared to the work, providing a good reservoir for a source of rapid heating.

Induction heating is fast and results are reproducible where a coil which surrounds but does not touch the work can be designed to induce a flow of current through the area to be heated. The method depends on the heat generated due to resistance to the flow of current. The current is induced into the conducting metal, but heating results from the flow of electrical current through the part.

Another method uses carbon tips to furnish heat by direct contact of a current source with the work. Any means of passing a current and using the resistance of the part or contacting surfaces can be used for heating. These methods help to keep the heating time to a minimum and avoid excessive oxidation.

Strength of Soldered Joints: The tensile strength of soft solder is about 4000 to 8000 psi compared to 40,000 to 80,000 psi for metals to be soldered—roughly 1/10. Thus it is necessary to have as large a contact area as practical for a strong joint. Various joint designs used to increase the soldered area, compared to a butt joint, are shown in *Fig.* 6.

The loads required to shear lapped joints 1 inch long are shown in *Fig.* 7 for 70-30 solder, 0.002-inch thick. It can be seen that the gain in strength is considerable for laps up to ½-inch.

The effect of solder thickness on the strength of a joint is shown in *Fig.* 8. In general a thickness of 0.002 to 0.003-inch is desirable for maximum strength. This requires good positioning or locating of the parts to be soldered, or crimping or locking of the part to the desired clearance. Such practices are also essential to assure no relative movement while the solder is freezing. Any movement while the solder is setting up will result in fractures and a weak joint.

If the joint will be exposed to heat in service the strength will be limited by the temperature. From *Fig.* 9, showing the decrease in strength with increase in temperature, it can be seen that the

Table 4—Solderability Rating

Metal	Rating
Tin and tin alloys	1
Silver	1
Copper and copper alloys	2
Steel	3
Nickel	3
Monel	3
Lead	4
Cadmium	4
Zinc	4
Stainless	5
Magnesium	6
Aluminum	6

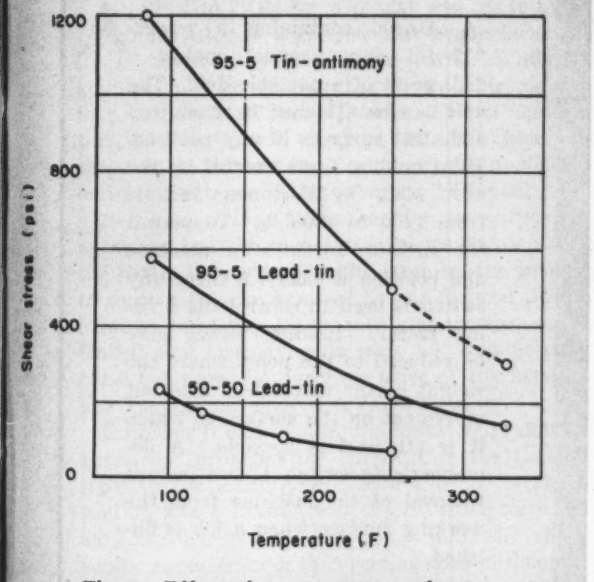


Fig. 9—Effect of temperature on shear strength of soldered sleeve joints†

strength extrapolates approximately to zero at the solidus temperature.

Solderability: Many production methods require easy and ready soldering. Relative ratings for the solderability of various metals, using lead-tin solders, are shown in *Table* 4. Tin is easily soldered because the solders melt the tin and readily alloy with it. Silver and copper also alloy readily with solder. With proper care the metals down to stainless can be soldered. The last two are difficult with common solders and fluxes. For easy soldering the various metals are often coated with a more solderable metal. This may be done either by hot dipping or by the electroplating process.

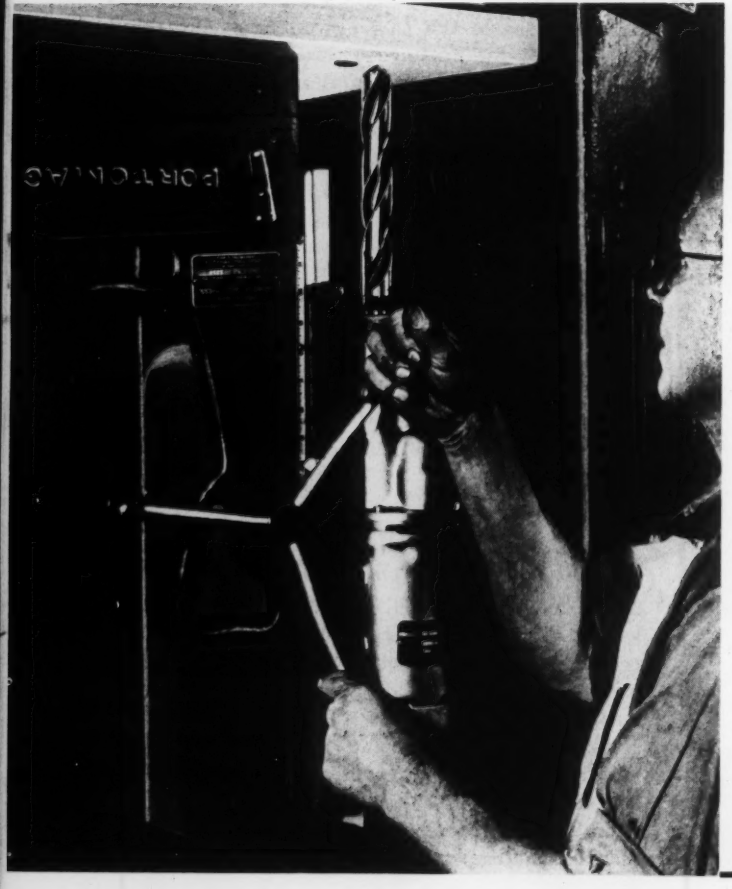
Copper wires are electroplated with tin for solderability. Although the solderability of copper is good, it tarnishes and after storage is not as readily soldered as a tin surface. Solderability is often a factor in the selection of electroplated coatings. Several corrosion-resistant tin alloys are used for electroplating of electric instrument parts. These tin-zinc and tin-copper-zinc alloys provide a surface for easy soldering. Copper alloy parts that are to be used for electrical connections are often plated with silver for good contact and good solderability.

Alloys that are difficult to solder can be electroplated with tin, copper, silver, lead-tin, nickel, zinc, cadmium or iron to increase solderability. Thus, many coatings are available so that one can be selected with other desirable surface properties for a particular application.

Hand soldering means provide a practical procedure for testing for solderability. For a simple estimation the spreading of a drop of solder will indicate the effect of the metal, the flux, the solder, the temperature, the surface and the cleaning method on solderability.

Contemporary Design

Magnetic Base Makes Drill Press Portable



A BASE containing a powerful electromagnet makes a drill press of a portable drill. The unit can be attached to most iron and steel surfaces in any position. Total holding force exerted by the unit, made by Portomag Inc., is from 1400 to 1900 lb. To permit the operator to shift the machine and position it easily, a three-way switch is used to control the holding power. Holding power may be reduced to the point where the weight of the machine is held but movement on the surface to which it is attached is possible. A demagnetizing switch allows instant removal of the machine from the working surface when a job is finished.

Patent Licenses and Assignments

. . . some practical facts about the granting of patent rights to another

By Albert Woodruff Gray
Forest Hills, N. Y.

Every patent confers upon the patentee three exclusive rights—the right to make, the right to use and the right to sell. Granting of any one or two of these features to another is a license. The grant of all three, however, is not a license but an assignment of the patent itself with its monopoly.

APPLICATION for a patent was made by the inventor of a grocery cart which telescoped horizontally into similar carts. While this application was pending the inventor transferred to a corporation "the exclusive right to manufacture, distribute, sell, develop and use" these telescope carts during the period of the application and for the term of the patent to be issued.

In consideration of this transfer, the corporation agreed to pay the inventor royalties on the sale of the carts. In a suit brought later by the inventor to recover the tax assessed by the Federal Government on these royalty payments as income, he contended that the payments were not taxable as income but were the purchase price of the invention and taxable as long-term capital gains.

However, it was held by the lower court that this agreement granting the corporation the exclusive right to the manufacture, sale and use of the invention was a license, and the royalties were ordinary taxable income. From this judgment the inventor appealed and, in reversing that decision and holding the agreement a sale of the invention and patent, the Federal Court of Appeals said; "It is a firmly accepted principle of law that if the patentee conveys by an instrument in writing the exclusive right to make, use and vend the invention throughout the United States, or an undivided part or share of the exclusive right, or the exclusive right under the patent within a specified area within the United States, the conveyance constitutes an assignment of the patent, complete or partial as the case may be; and that a transfer short of that is not an assignment but a license."

In conclusion the court said of this particular incident, "The contract constituted an assignment to the corporation of the invention relating to collapsible carts. Such assignment amounted to a sale of capital assets."

Another feature of this distinction between an assignment and a license of a patent occurred in a case before the Federal District Court in Delaware. Here the patentee had given "an exclusive, unlimited license to make, use and sell," the subject of the patent. Later, when the inventor attempted to bring an action for infringement against a licensee of the corporation to which this grant had been made, the court held that this patentee had assigned the patent and with it any rights he might have had to prevent its use by others.

Said the court, "If the conveyance vests in the alienee the entire interest in the invention or if it makes him a joint owner of the alienor in such an interest it transfers the monopoly to the same extent as the invention and is an assignment. But if it leaves in the alienor any exclusive right whatever in the invention or if the rights conferred on the alienee are not exclusive rights vesting in him alone or in him jointly with his alienor, the monop-

oly is not transferred and the conveyance is a license."

IN BOTH of these cases the courts followed in their decisions the law laid down by the Supreme Court of the United States in an opinion of Justice Taney, famous for his Dred Scott decision in Civil War days.

"The patentee may assign his whole interest or an undivided part of it. But if he assigns a part it must be an undivided portion of his entire interest under the patent, placing the assignee on an equal footing with himself for the part assigned. Upon such an assignment the patentee and his assigns become joint owners of the whole interest secured by the patent according to the respective proportions which the assignment creates.

"The patentee may assign his exclusive right within and throughout a specified part of the United States and upon such assignment the assignee may sue in his own name for an infringement of his rights. But in order to enable him to sue the assignment must undoubtedly convey to him the entire and unqualified monopoly which the patentee held in the territory specified—excluding the patentee himself as well as others. And any assignment short of this is a mere license.

"For it was obviously not the intention of the legislature to permit several monopolies to be made out of one and divided among several persons within the same limits. Such a division would inevitably lead to fradulent impositions upon persons who desired the purchase and use of the improvement and would subject a party who, under a mistake as to his rights, used the invention without authority, to be harassed by a multiplicity of suits instead of one and to successive recoveries of damages by different persons holding different proportions of the patent right in the same place.

"Unquestionably a contract for the purchase of any portion of a patent right may be good as between the parties as a license and enforced as such in the courts of justice. But the legal right to the monopoly remains in the patentee and he alone can maintain an action against a third party who commits an infringement upon it."

REFERENCES

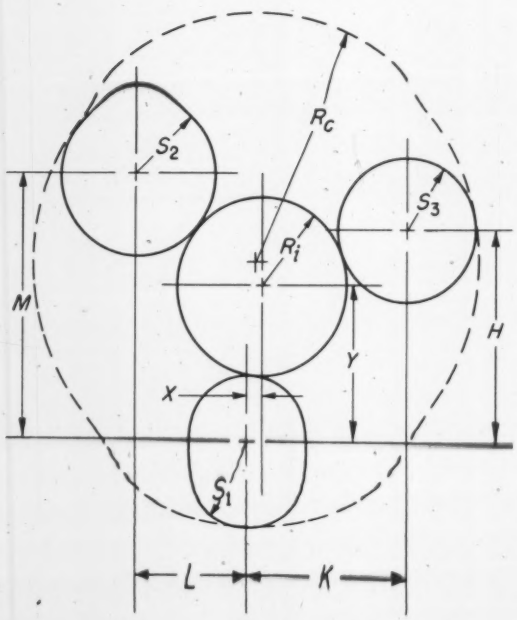
1. Watson v. United States, 122 *Fed. 2d* 689, May 12, 1955.
2. Preload Enterprises v. Pacific Bridge Co., 86 *F. S.* 976, October 28, 1949.
3. Gayler v. Wilder, 51 *U. S.* 477, December, 1850, Page 494.

Tips and Techniques

Finding Inscribed and Circumscribed Circles

A METHOD of finding the center location and radius of a circle tangent to three circles of equal diameter was shown in MACHINE DESIGN, Feb. 23, 1956, Page 126. A similar procedure describes a method of finding the location and size of either an inscribed or circumscribed circle tangent to three circles of unequal diameters.

In the accompanying sketch, co-ordinate axes have been chosen that pass through the center of the smallest circle. Equations 1 to 10 are used to find the letter distances. In Equation 7, use a minus sign before the radical to find distance X for an inscribed circle; use a plus sign to find X for a circumscribed circle.



$$A = S_2 - S_1 \quad (1)$$

$$B = S_3 - S_1 \quad (2)$$

$$C = \frac{BL + AK}{BM - AH} \quad (3)$$

$$D = \frac{B(L^2 + M^2 - A^2) - A(K^2 + H^2 - B^2)}{2(BM - AH)} \quad (4)$$

$$E = \frac{L - MC}{A} \quad (5)$$

$$F = \frac{L^2 + M^2 - 2MD - A^2}{2A} \quad (6)$$

$$X = \frac{EF - DC \pm \sqrt{(FC - DE)^2 + F^2 - D^2}}{1 + C^2 - E^2} \quad (7)$$

$$Y = CX + D \quad (8)$$

$$R_i = \sqrt{X^2 + Y^2} - S_1 \quad (9)$$

$$R_c = \sqrt{X^2 + Y^2} + S_1 \quad (10)$$

All three circles need not be of different radii. Any two of the circles may have equal radii; the only requirement is that S_2 be greater than S_1.

—Louis Ross, *Rockford, Ill.*

How to combine helical springs to obtain

Controlled Spring Force

By Ray C. Johnson
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IN DESIGN of experimental setups—and frequently in design of one-of-a-kind or limited-production items — a simple and economical method of developing zero or negative spring-force gradients is often required. These gradients (or spring constants) can be generated by special springs designed from flat stock. Because of their compactness and versatility, such special springs (Neg'ators) may be the best answer for quantity-production of final designs. But for preliminary development, or when the spring constant or spring magnitude must be adjustable, other solutions may be desirable.

This article presents a means for providing an adjustable-gradient, adjustable-magnitude spring force. The mechanism described uses two common helical springs. The helical spring has several advantages. It is easy to calculate, easy to make, and its force magnitude is quite simply adjusted. Unfortunately, under simple extension or compression, the helical spring has an inherent limitation: its force gradient is always positive.

The mechanism described in this article circumvents this limitation. Using simple helical springs, it produces force gradients ranging from positive to negative—including the special case of the zero gradient—and can easily be adjusted to give a desired force magnitude.

Forces and Gradients: Illustration of the meanings of the terms *spring gradient* and *force magnitude* is given in Fig. 1. Assume that the normally fixed end of the loosely wound helical spring is adjustable. When this end is fixed at position 1, the free end of the spring falls at the reference level (zero-load condition).

As a force is gradually applied to the spring, it deflects as shown by the solid line in the force-deflection plot. Slope of this curve is referred to as the *spring gradient, modulus,* or *spring constant.*

When the adjustable end of the spring is moved to position 2, the force-deflection curve is raised to the dashed line. Slopes of both curves are identical, and the spring gradient is unaffected by movement of the fixed end.

Note also in this example that the deforming force F increases in the direction of the deflection,

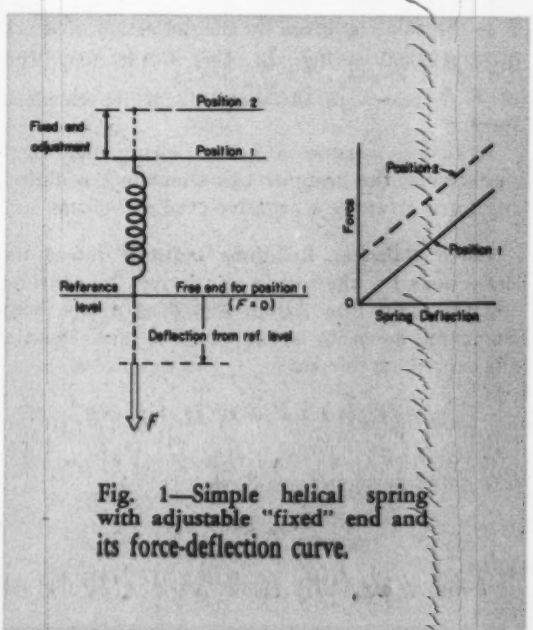

Fig. 1—Simple helical spring with adjustable "fixed" end and its force-deflection curve.

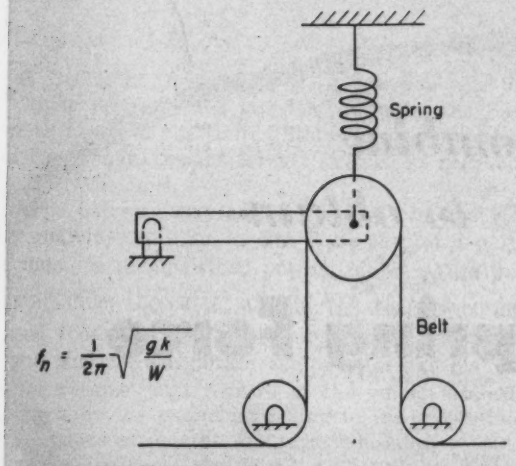

Fig. 2—Spring-loaded belt tension arm. Natural frequency f_n (insert equation) depends on effective weight W of arm-pulley assembly and spring gradient k. When $k = 0$, system has no resonant natural frequency and will not "run wild" under belt exciting forces.

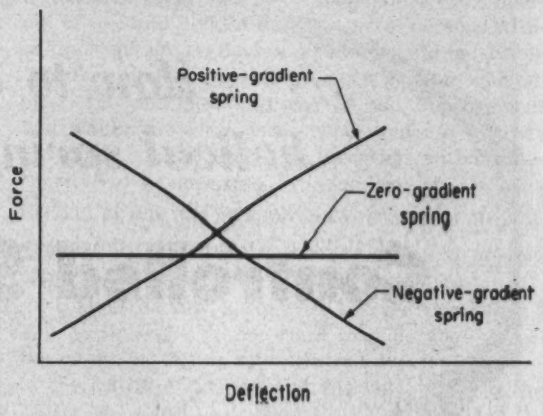

Fig. 3—Spring gradients with positive, negative and zero slopes.

and the spring therefore has a positive gradient. Helical springs always have positive gradients when deflected in simple tension or compression.

For certain mechanisms and experimental setups, zero-gradient spring forces are often required (Fig. 2). On other occasions it is desirable to provide negative spring gradients.

The three possible spring gradients are shown in Fig. 3. Here, as in Fig. 1, adjustment of force magnitude will shift the curves vertically without altering their slopes.

Negative-Gradient: A simple toggle mechanism is shown in Fig. 4 This mechanism uses a common helical spring, S_1 with a spring constant k_1. The pivot arm AD is held in equilibrium by an external vertical force F. Study of the figure shows that, as the arm moves downwards, variation in force F is the same as given by the deflection of a negative-gradient spring. In other words, magnitude of F decreases in the direction of movement of force F.

By using a common helical spring and toggle mechanism, the designer can simulate the deflecting force given by a negative-gradient spring.

Force Balance: Relations between forces and deflections for the toggle are derived by considering the pivot arm AD in Fig. 4 as a free body. Summing moments about point A and equating the expression to zero:

$$-FR\cos\theta + F_1 R\sin(\theta - \phi) = 0$$

The force developed by S_1 is

$$F_1 = k_1 (L - L_o)$$

If θ and ϕ are fairly small (i.e. $\theta < 15$ deg and $\phi < 15$ deg) then $\sin(\theta - \phi) \approx (\theta - \phi)$ and $\cos\theta \approx 1$.
Hence,

$$-FR + k_1 R (L - L_o)(\theta - \phi) = 0$$

Considering that θ and ϕ are small, and looking at similar triangles in Fig. 4,

$$\frac{R(\theta - \phi)}{y} = \frac{H}{L}$$

Therefore,

$$-FR + k_1 (L - L_o)\frac{Hy}{L} = 0$$

Rearranging,

$$F = k_1\left(1 - \frac{L_o}{L}\right)\frac{Hy}{R} \qquad (1)$$

Equation 1 shows that, for small angles of θ and ϕ, F is directly proportional to the displacement y. As discussed before, the effective spring gradient is negative.

Since spring gradient is the ratio of a deflection force to the deflection, the effective spring gradient of the toggle mechanism can be obtained directly from Equation 1. Hence, the effective gradient k_e of the simple toggle mechanism in Fig. 4 is

$$k_e = -k_1\left(1 - \frac{L_o}{L}\right)\frac{H}{R} \qquad (2)$$

From Equation 2, it is evident that the value of the negative spring gradient, k_e, can be changed by adjusting the position of pivot point B in Fig. 4. This is because the values of L and H change with movement of the pivot point. Hence, movement of point B in the horizontal direction can be con-

sidered as a gradient adjustment.

Adjustable Gradient and Magnitude: As a further consideration, suppose that the simple toggle mechanism in Fig. 4 is combined with another helical spring as shown in Fig. 5.

Since the spring S_2 in Fig. 5 is a helical spring, gradient k_2 is positive when considering its effect on the force F. Hence, from Equation 2 and using the law of superposition, the effective spring constant, k_e, for the force F is

$$k_e = k_2 - k_1 \left(1 - \frac{L_0}{L} \right) \frac{H}{R} \qquad (3)$$

Moving the fixed end of spring S_2 merely changes the magnitude of the force F. The gradient of S_2, and therefore the effective gradient k_e of the mechanism, is in no way changed by such a movement. It follows that a magnitude adjustment which is completely independent of the gradient adjustment can be made in the mechanism shown in Fig. 5.

From a study of Fig. 5 and Equation 3, several advantages of the mechanism are seen. For reasonably small values of θ and ϕ, the effective spring gradient k_e is constant as the pivot arm is swung from an upper to a lower position. Gradient k_e, however, is adjustable over both the negative and positive-gradient regions. Furthermore, the magnitude of force F is also independently adjustable.

The designer, therefore, can exert complete control over both the gradient and magnitude characteristics of force F by making simple adjustments in the mechanism of Fig. 5. Gradient limitations of the simple helical spring acting alone are overcome by merely using two such springs.

Sample Problem: In the belt-tension loading arm in Fig. 6 it is desirable to have a zero-gradient effective spring system that opposes arm movement between upper and lower limits. This system might be desirable to avoid dangerous critical frequencies and to maintain constant belt tension as the belt sprocket moves through its 1-in. range. Assume that the desired belt tension is ½ lb. The problem is to calculate

1. Suitable values for L_o, H, R, k_1 and k_2
2. Effect of adjusting point B ±⅛-in. horizontally.
2. Effect of adjusting point C ±¼-in. vertically.

1. *Dimensions and spring constants:* If $R = 2$

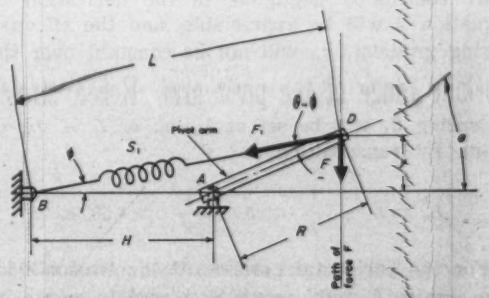

Fig. 4—Simple toggle mechanism with helical spring. Force F and spring S_1 hold arm AD in equilibrium.

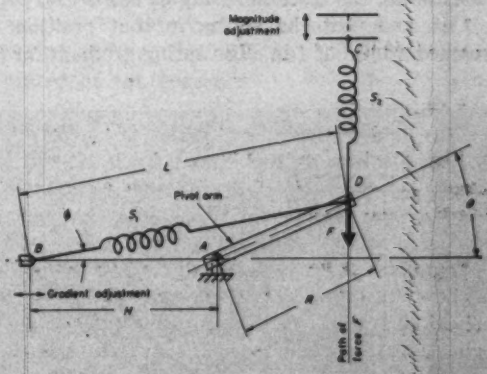

Fig. 5—Toggle mechanism with adjustments for spring gradient and magnitude.

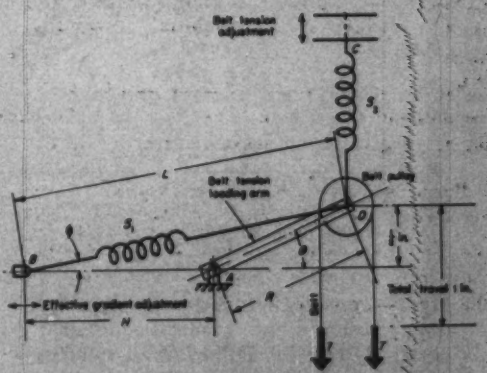

Fig. 6—Layout for belt-tension loading arm with spring gradient and magnitude adjustments.

Nomenclature

F = External vertical force required to maintain equilibrium at end of arm AD in Figs. 4 and 5, lb

g = Gravitational acceleration, 386 in. per sec²

H, L, R = Distances in Figs. 4, 5 and 6, in.

k_1 = Gradient, modulus or spring constant for helical spring S_1 in Fig. 4, lb per in.

k_2 = Gradient, modulus or spring constant for helical spring S_2 in Fig. 5, lb per in.

k_e = Equivalent gradient as felt by F in the mechanism of Fig. 5, lb per in.

L_o = Free, unstretched length of member connecting points B and D in Fig. 4, in.

y = Vertical displacement of endpoint of arm in Fig. 4 from position where $F = 0$, in.

θ, ϕ = Angles in Figs. 4 and 5, radians, unless otherwise specified

in. in Fig. 6, then $\theta_{max} = \sin^{-1} \frac{1}{2}/2 = 14.3$ deg. This is a reasonably small angle.

Next, assume that H is 3 in. Generally, H should be equal to or greater than R; otherwise, an impractically large value for k_1 is sometimes needed. For small θ and ϕ,

$$L \approx H + R = 3 + 2 = 5 \text{ in.}$$

which is the stretched, working length of the link BD in Fig. 6.

Generally, it is desirable to have an appreciable stretch in spring S_1. Otherwise differentials which were considered negligible in the derivation of Equation 2 will be appreciable, and the effective spring gradient, k_e, will not be constant over the working range of the pivot arm. Hence, stretch of spring S_1 will be set at ½-in., or $L - L_o =$ ½-in. By transposition,

$$L_o = L - \frac{1}{2} = 5 - \frac{1}{2} = 4.50 \text{ in.}$$

For the horizontal position of the tension-loading arm in Fig. 6, spring S_1 obviously exerts no force effect on the belt tension. Belt tension at that position is obtained directly from the spring S_2. Assume that when the pivot arm in Fig. 6 is horizontal, the force in spring S_2 is $2\,T = 2(\frac{1}{2}) = 1$ lb and that the spring in that position is stretched a total of 1 in. The spring gradient for S_2 is the force divided by the total deflection, or $k_2 = 1/1 = 1$ lb per in.

Substituting the values calculated so far in Equation 3 and equating k_e to zero,

$$0 = 1 - k_1 \left(1 - \frac{4.5}{5}\right)\left(\frac{3}{2}\right)$$

Therefore,

$$k_1 = 6.67 \text{ lb per in.}$$

In summary, the following values are suitable for the belt-tensioning mechanism: $L_o = 4.5$ in., $H = 3$ in., $R = 2$ in., $k_1 = 6.67$ lb per in., $k_2 = 1.0$ lb per in.

The springs S_1 and S_2 are simple helical extension springs, and normal spring design procedures should be employed.

2. *Effect of change in gradient adjustment*: To determine the effective spring-gradient change due to a $\pm\frac{1}{8}$-in. movement of point B in Fig. 6, examine Equation 3. If $H = 3 + \frac{1}{8}$, and L_o, R, k_1 and k_2 remain the same as in the preceding section, Equation 3 gives

$$k_e = 1 - 6.67 \left(1 - \frac{4.5}{5.125}\right)\left(\frac{3.125}{2}\right)$$

since $L = H + R$.

Therefore, $k_e = -0.270$ lb per in. for the case where point B in Fig. 6 has been moved so that $H = 3.125$ in. On the other hand, the same procedure for the case where H has been decreased by ⅛-in. to 2⅞ in. gives an effective spring gradient of $k_e = +0.263$ lb per in.

From an exact static equilibrium consideration of the pivot arm, values of the force $F = 2\,T$ in Fig. 6 can be calculated for various positions of point D. Fig. 7 shows results obtained for three positions of point B and for a range of movement of D both inside and outside the expected working range. It can be seen that the curves are essentially linear within the working range, where θ and ϕ are both less than 15 deg. In this range, no force deviates more than 3 per cent from the straight line. Nonlinearity is quite apparent, however, when point D moves outside the expected working range. The curves illustrate the importance of staying within the specified working range if linearity of gradient is important.

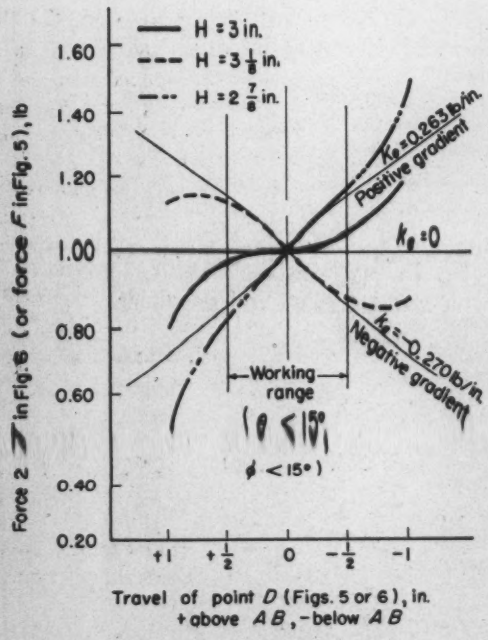

Fig. 7—Force-deflection characteristics for three positions of gradient-adjustment point, B, Fig. 6. Pulley travel, plotted on horizontal axis, has been extended beyond specified working range to show how force-deflection curve departs from linearity.

To summarize the gradient adjustment study: movement of point B in Fig. 6 to the right results in steeper positive effective gradient; movement of point B to the left results in a steeper negative effective gradient.

3. *Effect of change in belt-tension adjustment*: When point C is moved through a $\pm\frac{1}{4}$-in. vertical range (Fig. 6), the force magnitude variation is $\pm(\frac{1}{4})\ (k_2) = \frac{1}{4}$-lb, where $k_2 = 1$ lb per in. The resulting change in belt tension is therefore $\pm\frac{1}{8}$-lb.

Vertical adjustment of point C merely translates the force-deflection curves in Fig. 7 vertically without changing their slopes.

Vector analysis and design charts simplify

Brake Design

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BRAKE analysis is usually a tedious problem because complex integrations must be performed and solved for each particular case. Furthermore, many trial and error solutions must usually be attempted before a reasonable and satisfactory design is obtained. This article presents a simplified method for arriving at an initial solution which, with other graphical aids, can be applied to block and shoe type brakes of the translating and rotating types. Although testing of a prototype is always advisable, this method provides easy visualization of the influences exerted by the various parameters upon brake design and may facilitate any final adjustments required of the design.

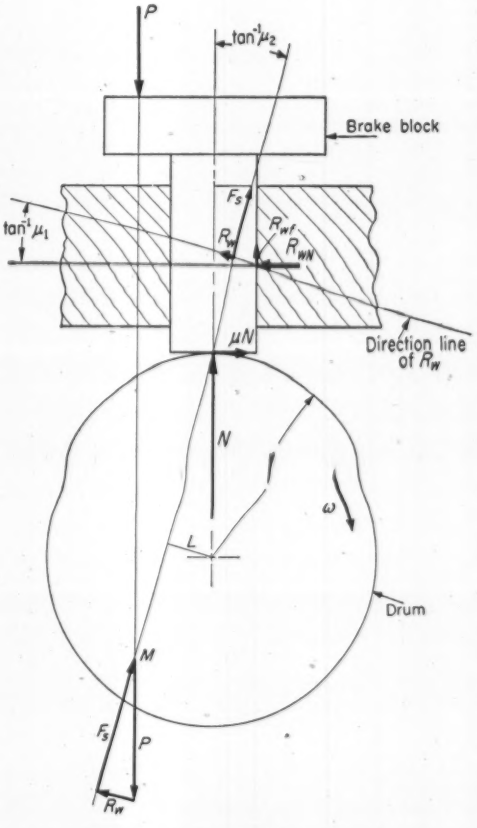


Fig. 1 — Translating block brake with point contact.

Translating block brake with point contact is shown in Fig. 1 along with its analysis. The three forces that act on this shoe, and concur in one point, are recognized as the applied force P, the wall reaction R_w and the braking force F_s. Direction of force F_s is known from friction angle $\tan^{-1}\mu_1$ and that of R_w from $\tan^{-1}\mu_2$.

A vector force diagram can be plotted and evaluated for F_s and R_w for a given value of P by assignment of appropriate scales to the legs of the triangle. The stopping torque which is numerically equal to μNr, is also equal to F_s multiplied by its moment arm, L, which can be easily scaled off the layout.

Rotating block brake with point contact is shown in Fig. 2. In the same manner, this design can be analyzed by replacing the wall reaction with the pin reaction R_p. If, for example, the applied force P is assumed to be 100 lb, vector solution of Fig. 2 shows that $F_s = 100\ (2.125/1.0) = 212.5$ lb; $R_p = 100\ (1.375/1.0) = 137.5$ lb; and $T = F_sL = 212.5\ (0.9) = 191$ lb-in.

Effect of pivot point upon sensitivity of the brake is demonstrated in Fig. 3. From the vector force triangles, it can be observed that as the pivot point E is shifted toward the direction line of F_s, as shown by point E_2, a greater force F_s can be obtained for the same applied force P. As the pivot point is moved to the direction line of F_s at

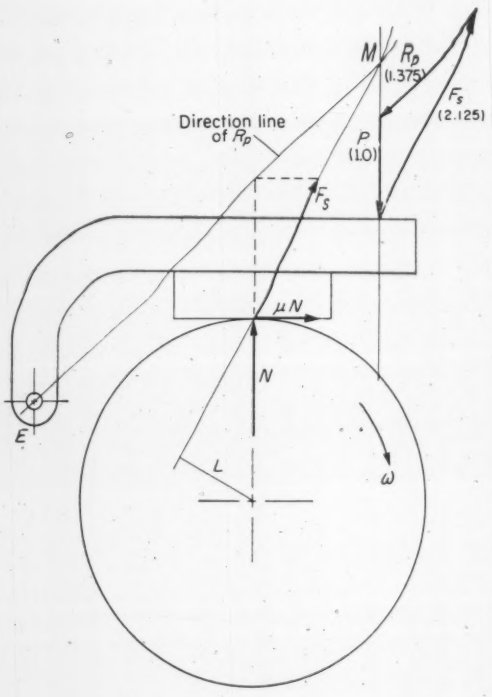


Fig. 2 — Rotating block brake with point contact.

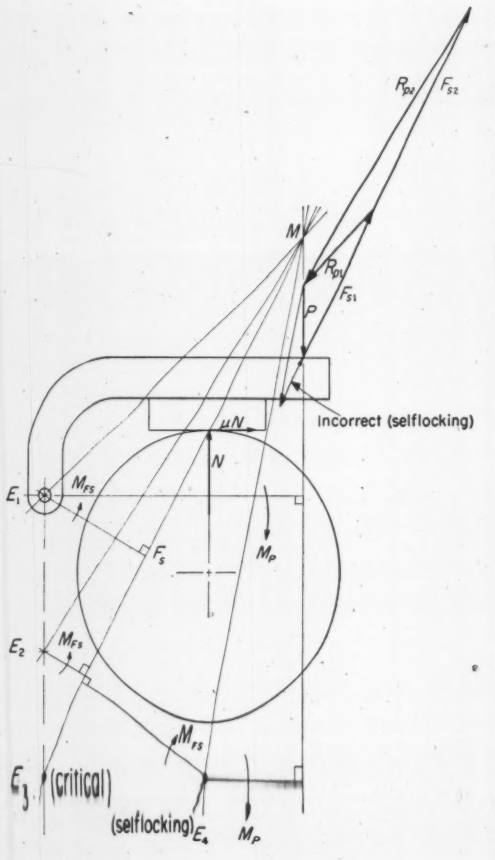


Fig. 3—Effect of moving pivot point *E* in design of Fig. 2.

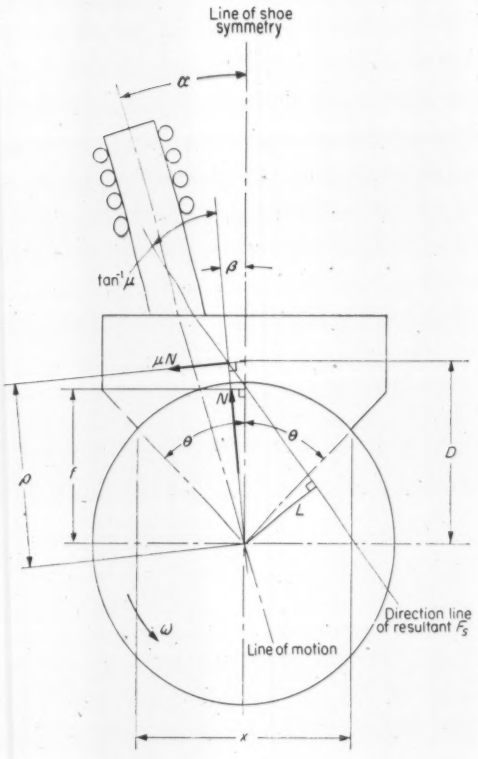


Fig. 4—General case of translating brake with area contact.

Nomenclature

A = Developed brake-shoe area, sq in.
A_p = Projected brake-shoe area, sq in.
b = Shoe width, in.
C = Design constant, dimensionless
D = Distance from center to intersection of μN with axis of symmetry, in.
F_s = Braking force, lb
f = Projection of r through angle α, in.
K = Power absorption constant
L = Moment arm to F_s, in.
N = Normal force, lb
μN = Friction force, lb
n = Velocity, rpm
P = Applied force, lb
p_{max} = Maximum shoe surface pressure, psi
R_p = Pivot reaction, lb
R_w = Wall reaction, lb
r = Brake drum radius, in.
S = Pressure-velocity constant
T = Braking torque, lb-in.
v = Velocity, fps
α = Orientation of line of motion relative to axis of symmetry, deg
β = Orientation of N relative to axis of symmetry, deg
θ = Half brake-shoe angle, deg
$\pi\theta/180$ = Half brake-shoe angle, rad
ρ = Moment arm of μN, in.
μ = Coefficient of friction
ω = Velocity, rad per sec

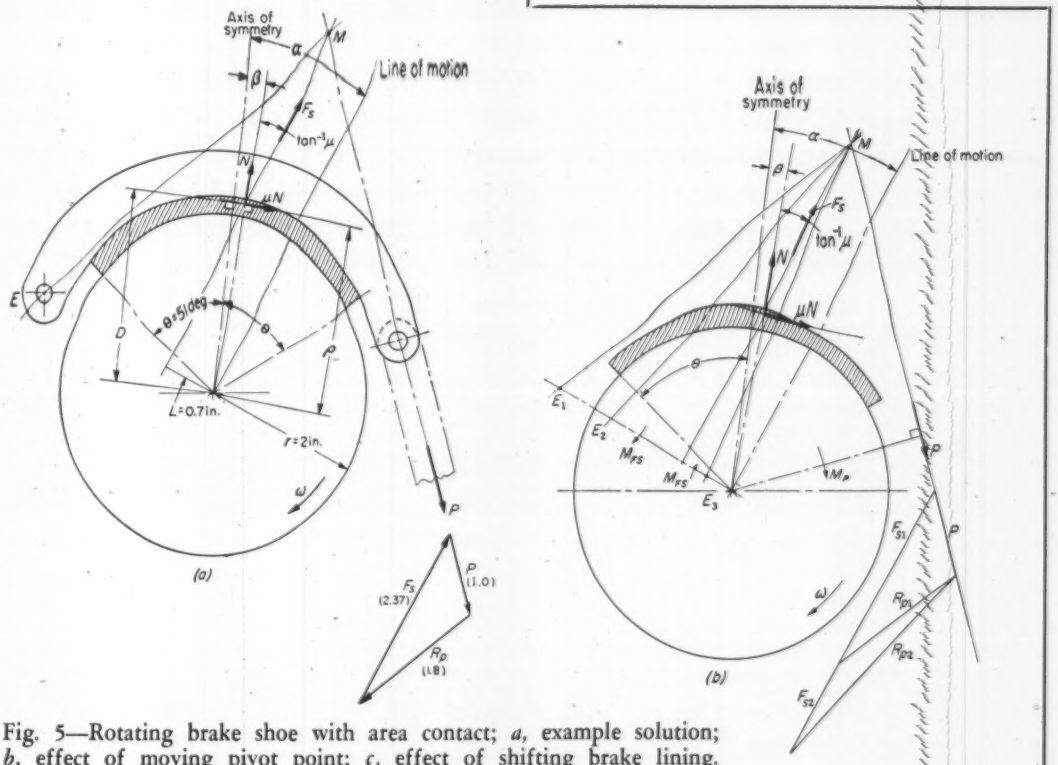
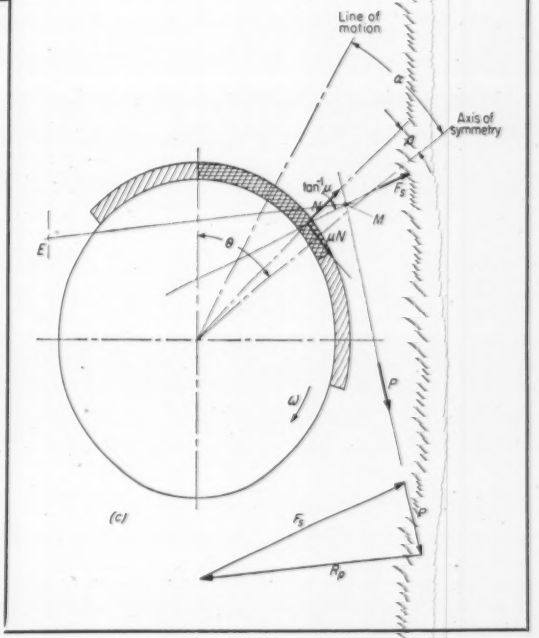


Fig. 5—Rotating brake shoe with area contact; *a*, example solution; *b*, effect of moving pivot point; *c*, effect of shifting brake lining.



E_3 and past it to point E_4 an incorrect force relationship results.

This is the consequence of an incorrect force direction and indicates a condition of selflocking. There is another way to check for selflocking. The moment created by the force P about the pivot point E_4 takes the same direction as the moment of force F_s about this point. Thus, these two forces "double up" and create a selflocking effect.

If the moments of F_s and P are in the same direction, the brake becomes "supersensitive" and selflocks. If they are in opposite directions, selflocking will not occur.

Translating or rotating shoe brakes with area contact are more complicated problems, Fig. 4. They can be solved graphically in a manner similar to the foregoing cases if the direction of the resultant of all infinitesimal normal and frictional forces acting on the shoe can be found. For convenience, the same symbols—F_s, N, μN—will be used. A basic method will be established, Fig. 4, and then applied to other examples, Fig. 5.

The resultant brake stopping force F_s is obtained as the vector sum:

$$F_s = N + \mu N$$

Angle β, which defines the direction of N from the axis of symmetry, is obtained from

$$\tan \beta = \frac{2\theta - \sin 2\theta}{2\theta + \sin 2\theta} \tan \alpha \qquad (1)$$

This equation has been developed by use of a wear concept which conveniently provides a relationship between the infinitesimal normal forces and the angles θ and α. The graph of Fig. 6 solves Equation 1.[3]

Moment arm ρ is obtained by summing up all frictional forces acting on the shoe and again applying the wear concept:

$$\rho = \frac{4 \sin \theta}{2\theta + \sin 2\theta} r \cos \beta$$

Eliminating β by the relationship $\rho/D = \cos \beta$ leads to

$$\frac{D}{r} = \frac{4 \sin \theta}{2\theta + \sin 2\theta} \qquad (2)$$

Another useful relationship, based upon the geometry evident in Fig. 4, is

$$\frac{L}{r} = \frac{D}{r} \cos \beta \sin (\tan^{-1} \mu) \qquad (3)$$

Equations 1, 2 and 3, and their graphical solutions in Figs. 6 and 7, are helpful in analyzing more complex brake problems.

Rotating shoe brake with area contact is shown in Fig. 5. Assume that the drum rotates at 1000 rpm, and P = 100 lb. Coefficient of friction μ = 0.35. The problem is to find the stopping torque, the pin reaction and the absorbed horsepower.

From the geometry of the shoe, θ = 51 deg. Assume that α is determined to be 22.5 deg. From Fig. 6, angle β = 6.6 deg and from Fig. 7, D/r = 1.125. Hence, $D = 1.125r = 1.125(2.0) = 2.25$ in., which is laid off on the axis of symmetry, Fig. 5*a*.

Angle β is now drawn in from the axis of symmetry, setting the direction of normal force N. Perpendicular to this line, and passing through the upper end of distance D, the direction line of μN is drawn establishing distance ρ. Next, the friction angle is laid off; it is the angle $\tan^{-1}\mu$. This angle gives the direction line of F_s, which is continued to intersect with the direction line of P at M.

Connecting the pivot point E with point M establishes the direction line of the pin reaction R_p. The vector force triangle can now be developed with a scale of 1 in. = 100 lb, and the legs of the triangle drawn parallel to the respective force direction lines, R_p = 100 (1.8/1.0) = 180 lb and F_s = 100 (2.37/1.0) = 237 lb.

Stopping torque T can be obtained by scaling the distance L or by employing Fig. 7 to get L/r and multiplying the value obtained from the graph by r to obtain L. Then, $T = LF_s$ = (0.7) 237 = 166 lb-in.

The absorbed horsepower is simply $Tn/63{,}000$ = 166 (1000)/63,000 = 2.6 hp.

Here again the same criterion can be applied for selflocking. It is readily recognized that moving of the pivot E along a line toward the center will not affect the brake geometry, Fig. 5*b*. Angles α, β, and directions of N and P are unaffected. Only the direction line of R_p will be changed. When the pivot moves past the line of F_s, the brake will become selflocking.

Another variation in the brake design may be created by shifting the brake shoe only, leaving all other geometrical properties as before, Fig. 5*c*. Parameters α and β change. Comparison of the resulting vector triangles establishes the new relationship of forces.

In most brake designs the allowable maximum pressure on the shoe is one of the principal criteria limiting the design. The maximum pressure can

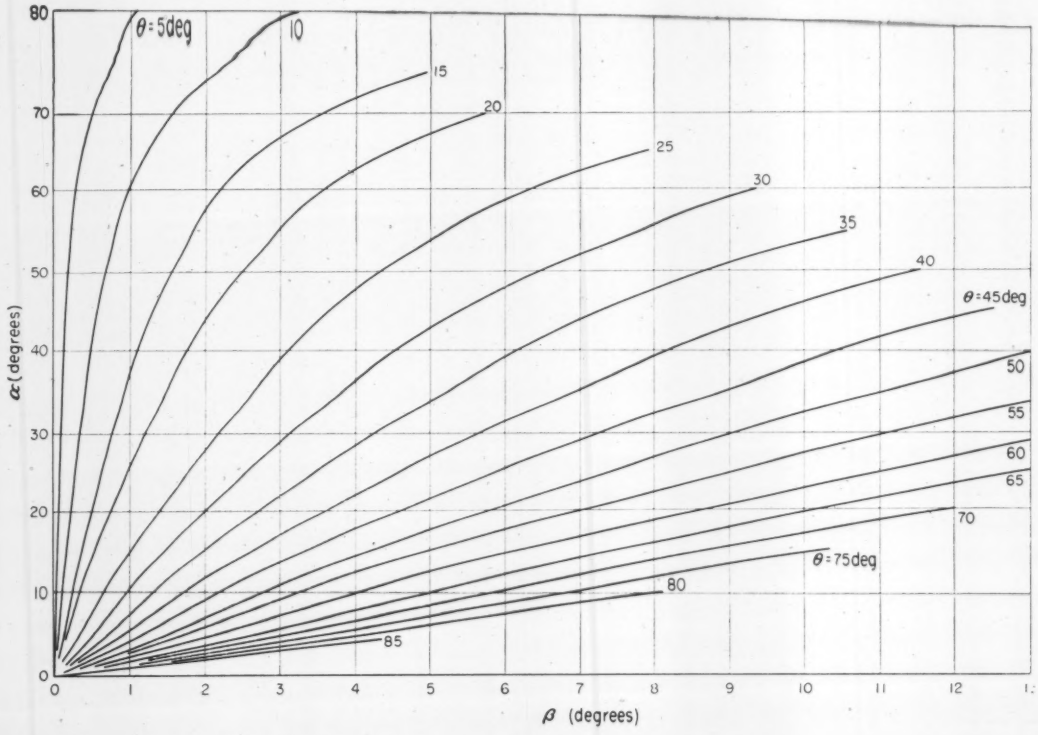


Fig. 6—Graph relating angles α, β and θ.

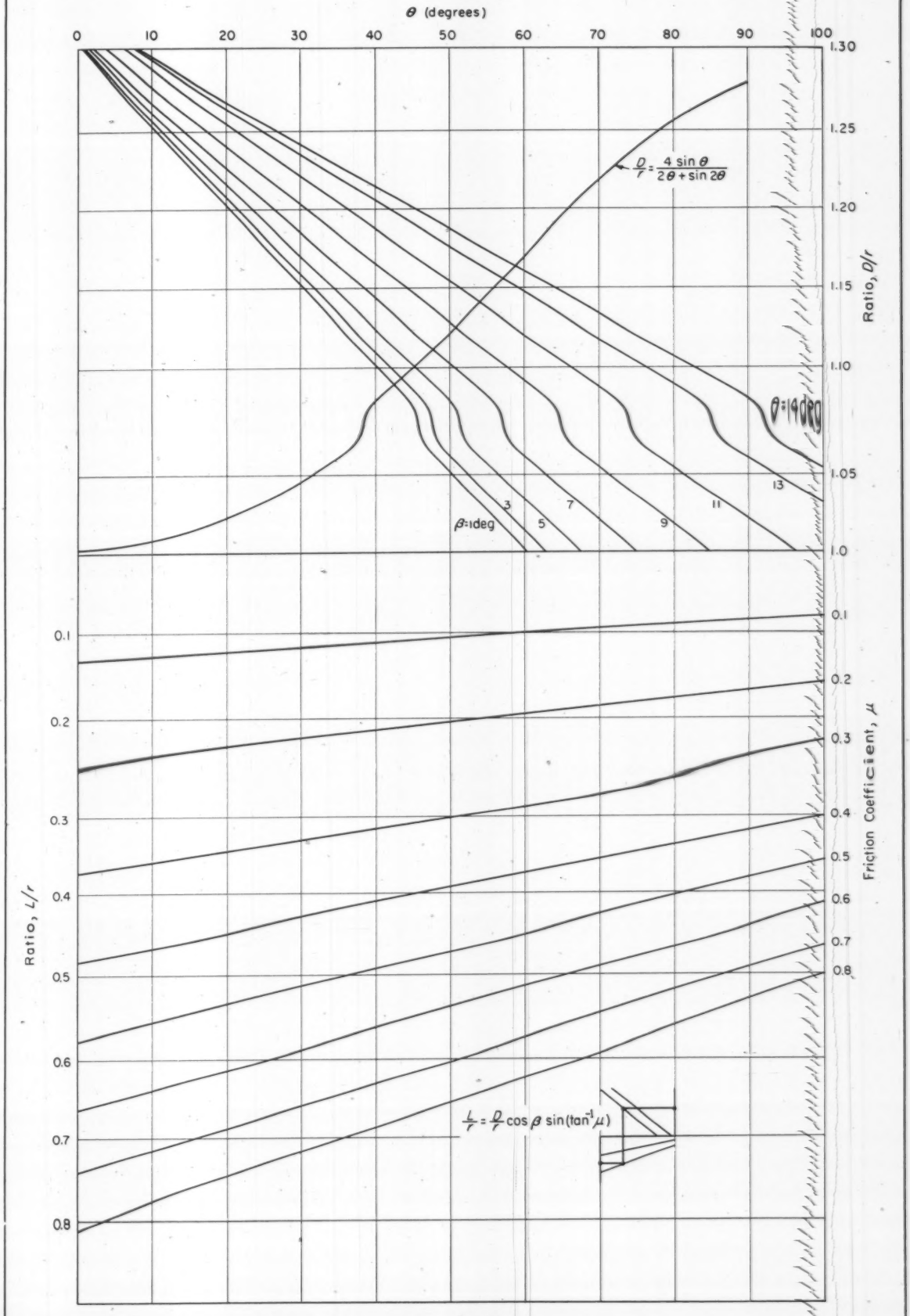


Fig. 7—Chart for calculations involving L/r, D/r, β and μ, as well as D/r and θ.

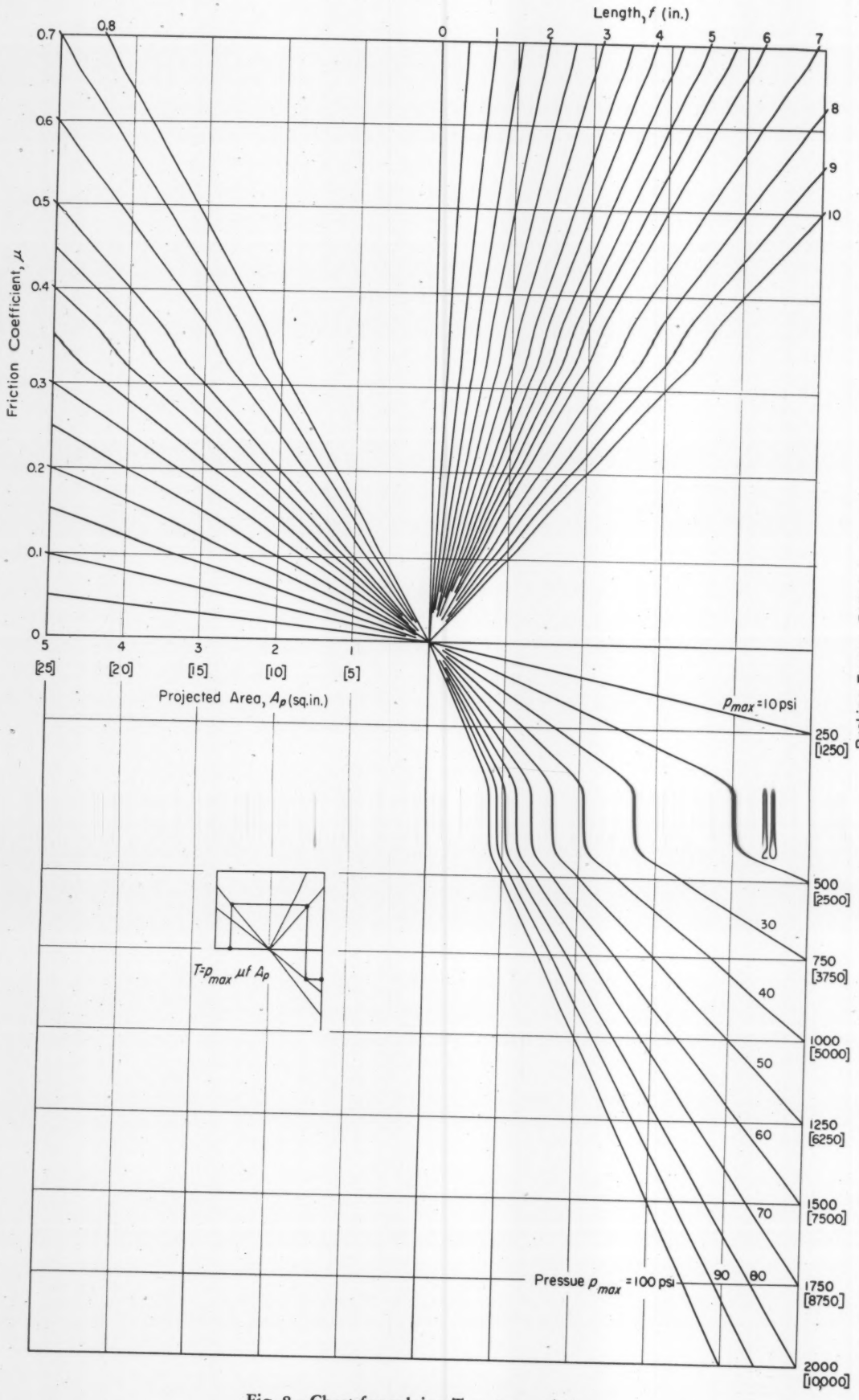


Fig. 8—Chart for solving $T = p_{max}\ \mu\ f\ A_p$.

be shown to be related to the stopping torque as follows:

$$T = \frac{p_{max} A_p f \mu}{\cos(\theta - \alpha)}$$

Since the pressure is maximum at the line of motion, which is specified in most brake designs, this equation can be simplified to

$$T = p_{max} A_p f \mu \qquad (4)$$

Equation 4 is presented graphically in Fig. 8.

Automobile type brake, Fig. 9, provides another example. Assume that the brake shoe can safely withstand 75 psi; $\mu = 0.5$, $\vartheta = 45$ deg, width $b = 1.0$ in., radius $r = 2.5$ in. By the geometry of the shoe and pivot point, $\alpha = 18$ deg. The problem is to find the maximum force P which the hydraulically operated piston should exert, the resulting combined stopping torque, and the individual pin reactions.

Since θ and α are the same for both shoes, identical values of β are obtained from Fig. 6; $\beta = 4.1$ deg which is laid off as shown in Fig. 9. From Fig. 7, $D/r = 1.1$, from which $D = 2.75$ in.

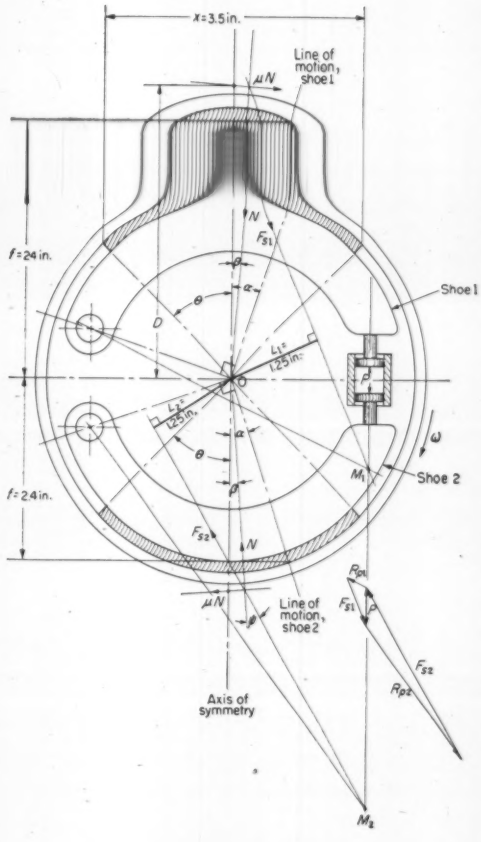


Fig. 9—Solution for automotive type brake.

which is laid off on the axis of symmetry. Direction line of μN is drawn through end of D and perpendicular to direction line of N.

Friction angle $\tan^{-1} 0.5$ is laid off giving the direction line of the resultant F_s. The intersection of F_s and P at point M is connected to the pivot point to give the direction line of R_p. Identical procedure for both shoes establishes M_1 and M_2 and, in turn, all the direction lines. The vector force diagram can now be plotted as shown in Fig. 9. Leg P is made the same for both shoes, since the piston exerts equal pressure in both directions. Distance f is scaled to be 2.4 in., and the projected area of the brake shoe is $A_p = xb = 3.5\ (1.0) = 3.5$ sq in.

These results, together with $p_{max} = 75$ psi and $\mu = 0.5$, are used in Fig. 8 to obtain stopping torque $T_2 = 315$ lb-in. Since the vector force triangle indicates a greater force F_s for shoe 2, this shoe obviously will determine force P.

From the brake layout, Fig. 9, distance L_2 is established as 1.25 in. Force $F_{s2} = T_2/L_2 = 315/1.25 = 250$ lb. The remaining forces are determined from the vector diagram: $R_{p1} = 30$ lb, $R_{p2} = 215$ lb, $P_1 = P_2 = P = 50$ lb and $F_{s1} = 67$ lb.

The total stopping torque is $T_t = T_1 + T_2$; $T_1 = F_{s1} L_1 = 83$ lb-in. Torque T_2 has already been determined to be 315 lb-in. Therefore, $T_t = 83 + 315 = 398$ lb-in.

For optimum results in brake shoe design the additional factors of horsepower absorption and pressure-velocity limitations must be taken into consideration. Power absorption factor K is usually assumed between 0.2 and 0.3 hp per sq in. of shoe area, and the pressure-velocity factor $S = pv$ depends upon the application, as follows:

$S \leqq 28{,}000$	Continuous, poor heat dissipation
$S \leqq 55{,}000$	Intermittent, long periods of rest
$S \leqq 83{,}000$	Continuous, good heat dissipation

A useful design parameter can be developed from Equation 4 and from two other basic relationships: $K = Tn/63{,}000A$ and $p_{max} = 6\ S/\pi rn$. It is the dimensionless factor,

$$C = \frac{33{,}000\ K}{S\ \mu} = \frac{\cos\alpha \sin\theta}{\frac{\pi\theta}{180}} \qquad (5)$$

which is expressed graphically in Fig. 10.

Initiating a new brake design generally proceeds from certain already established design parameters, such as S, K, μ, p_{max}, T and n. Then, it is required to find the following parameters: r, A, θ, b, P, R_p and α.

In a particular example, Fig. 11, assume the following values as given: $p_{max} = 25$ psi, $T = 1500$ lb-in., $\mu = 0.4$, n 500 rpm, $S = 28{,}000$, and $K = 0.3$. Then,

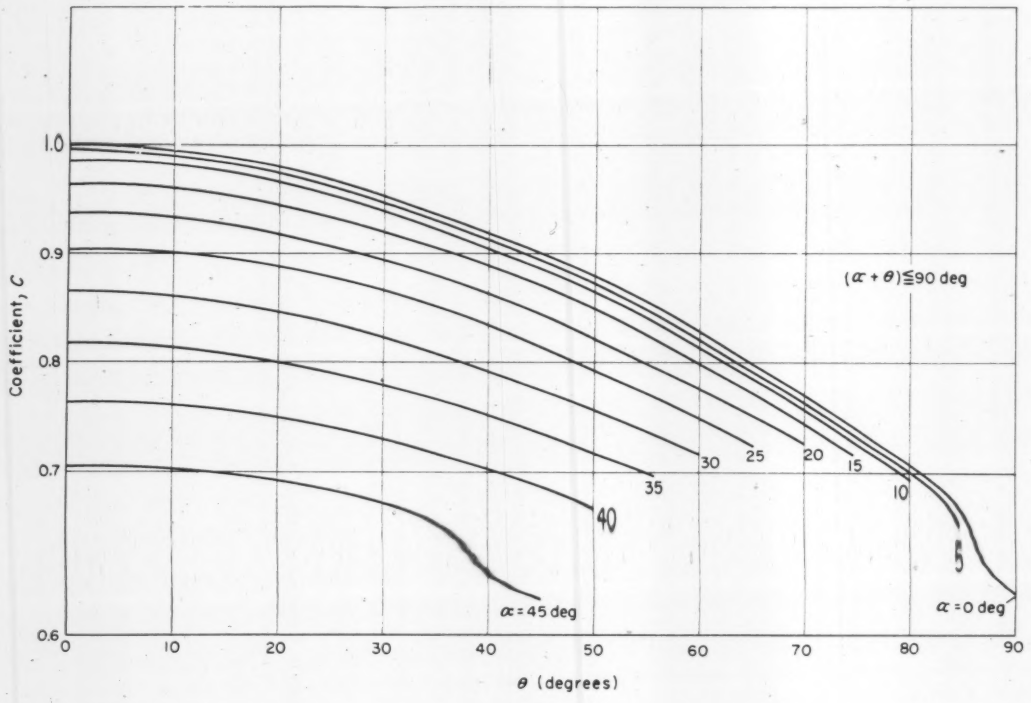


Fig. 10—Graph for finding design constant C from angles α and θ.

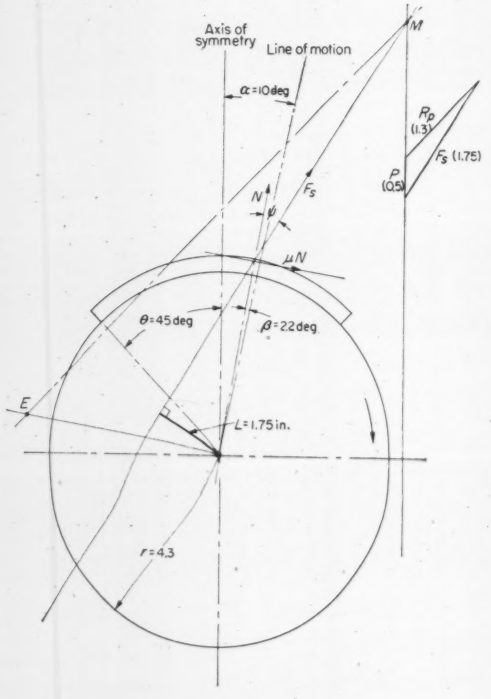


Fig. 11—Example showing how solution of brake problem proceeds from certain initial requirements.

$$r = \frac{6\,S}{\pi n\,p_{max}} = \frac{6\,(28{,}000)}{\pi\,(500)\,(25)} = 4.3 \text{ in.}$$

$$A = \frac{Tn}{63{,}000\,K} = \frac{1500(500)}{63{,}000(0.3)} = 40 \text{ sq in.}$$

$$C = \frac{33{,}000\,K}{S\,\mu} = \frac{33{,}000\,(0.3)}{28{,}000\,(0.4)} = 0.886$$

Since the geometry of the shoe is somewhat arbitrary and dependent upon the surrounding parts configuration, the values of α and θ can be picked off Fig. 10 for the correct value of C = 0.886 to meet the design conditions. It should be emphasized that for good design $\alpha + \theta$ should be less than 90 deg. For this case θ is taken as 45 deg and α as 10 deg. The width of the shoe is

$$b = \frac{A\,(180)}{2\,r\,\theta\pi} = \frac{40\,(180)}{2\,(4.3)\,(45)\pi} = 5.9 \text{ in.}$$

If b appears too large to suit the design, the braking moment T can be separated into T_1 and T_2, and two individual brake shoes used to take the total moment T_t. Next β = 2.2 deg and D/r = 1.1 from Figs. 6 and 7. Finally the forces P and R_p are solved by the force triangle which is obtained from the layout. As shown in Fig. 11, F_s = 1500/1.75 = 857 lb, P = 245 lb and R_p = 635 lb.

DESIGN ABSTRACTS

Designing Bearings with Nylon and Teflon Plastics

By A. J. Cheney, W. B. Happoldt and K. G. Swayne
E. I. du Pont de Nemours and Co. Inc.
Wilmington, Del.

PROPERTIES of Teflon and nylon, and their behavior under little or no lubrication, make them interesting bearing materials for many applications. The following discussion covers, first, the design aspects of Teflon (polytetrafluoroethylene or PTFE), then considerations for nylon, and finally the chief factors involved in selecting one or the other of these two materials for bearing applications.

Tetrafluoroethylene Plastic

Teflon possesses a number of properties which make it an interesting bearing material. The most important is that under certain conditions a very low coefficient of friction, approximately 0.04 or less, can be obtained with nonlubricated bearings. Low coefficients of friction can be obtained even with compositions containing fillers to improve the wear properties.

General properties of molded Teflon are listed in Table 1. PTFE has the highest melting point of any of the thermoplastics, since it melts at 620 F. It has excellent

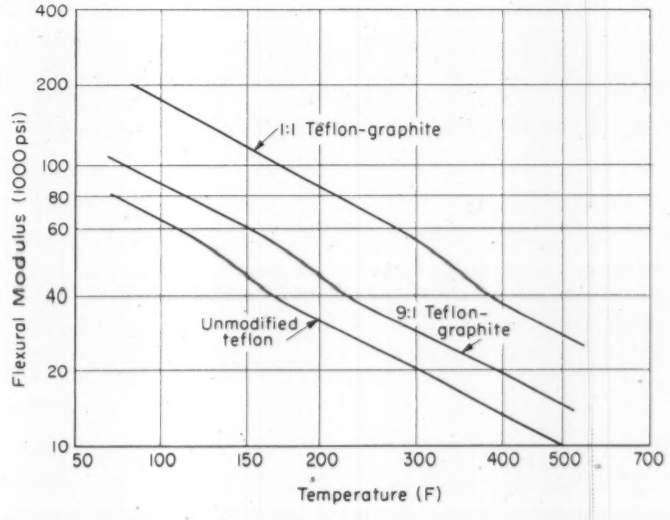


Fig. 1—Effect of temperature on flexural modulus of filled and unfilled Teflon.

Table 1—General Properties of Molded Teflon

Melting point	620 F
Upper service limits	
Continuous	500 F
Intermittent	620 F
Coefficient of thermal expansion	5.8×10^{-5} in./in./deg F
Transition point at 70 F results in linear increase of	0.004-in./in.
Thermal conductivity	1.7 Btu/hr/sq ft/deg F/in.
Hardness	
Rockwell	J75-95
Durometer	D50-D65
Knoop	2.8
Compressive strength at 1 per cent deformation	
At 73 F	600 psi
Fatigue endurance limit	
At 73 F	780 psi

stability to heat and can be used continuously at temperatures up to 500 F and intermittently up to 620 F.

Strength and hardness properties are also shown. Because it is a soft but tough material, it will embed the hard foreign contaminants that are often found in a bearing.

Teflon also is inert to a wide range of chemicals and solvents. Parts made from this material will neither be affected by nor contaminate their environment, except for a few chemicals seldom encountered in industry, such as molten alkali metals and fluorine at elevated temperatures and pressure. In addition, water has no effect on this material.

Various combinations of PTFE with reinforcing agents such as graphite or powdered glass are commonly used for bearings and other mechanical applications which require good resistance to wear. In general, the physical properties of these combinations are the same as those of straight Teflon, except that the reinforced stocks have much better resistance to deformation and wear.

Short-time deformation properties, as measured by the flexural modulus, are shown in Fig. 1. The modulus is a function of the temperature and the amount of additive used. The ratios of the two compositions containing graphite are by weight. If the modulus of any given composition is known at one temperature, the value can be estimated accurately for other temperatures from this chart since the lines are parallel.

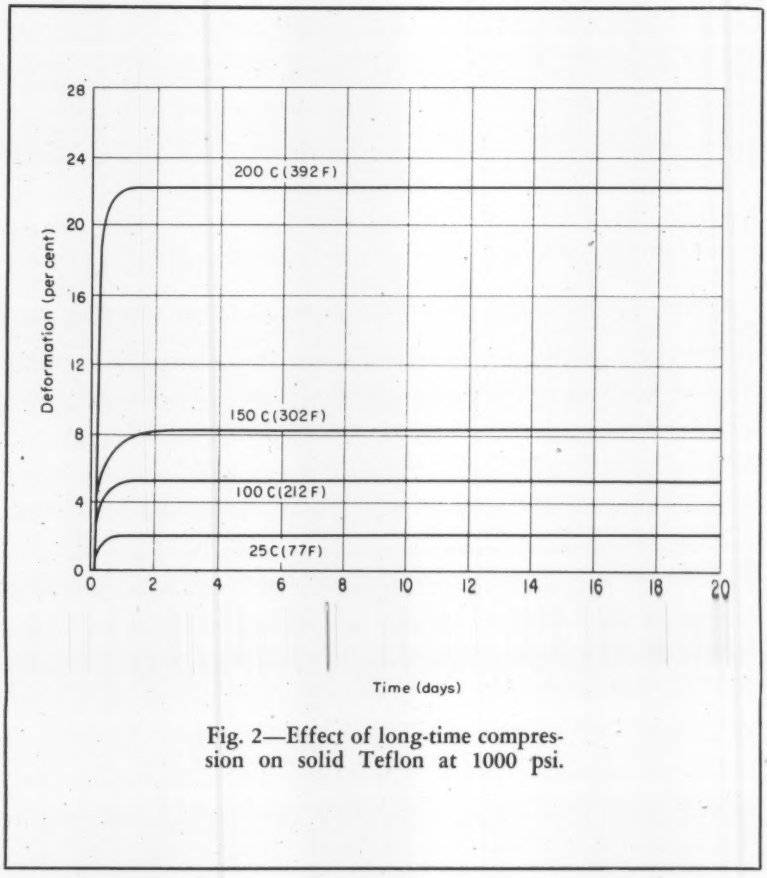


Fig. 2—Effect of long-time compression on solid Teflon at 1000 psi.

As with many materials, the moduli in flexure, tension, and compression are essentially the same. Therefore, the compressive stress to give 1 per cent deformation for the modified compositions increases in the same proportion as the modulus. For example, the 1:1 Teflon-graphite composition has a modulus three times that of unmodified material; therefore, the compressive stress at 1 per cent deformation is 3 × 600 or 1800 psi for this material.

The deformation produced by a long sustained load is shown in Fig. 2. After the initial deformation, the part continues to deform for a short time, and then changes little over long periods. This deformation can be accounted for in design by using a reduced value for the modulus. These values, called an apparent modulus, are plotted against temperature in Fig. 3. To calculate the total deformation that will occur after two or more days under load, simply divide the unit stress by the apparent modulus.

Table 2—Effect of Rubbing Speed on the Coefficient of Friction of Teflon

Apparatus	Approximate Rubbing Speed (ft/min)	Coefficient of Friction
Sliding hemisphere	0.02–2.0	0.04
Sliding hemisphere	0.02	0.04–0.1
Flat ring	Hand turning	0.016
Crossed cylinders..	8	0.09
	367	0.21
Rotating cylinder.	2	0.05–0.08

Frictional Properties: Coefficient of friction of PTFE is considerably less than for such familiar dry lubricants as molybdenum disulfide and graphite, which have values of about 0.09 to 0.12. These two additives in Teflon cannot be expected to cause a further reduction in friction under the conditions where the low coefficients are obtained, Fig. 4.

Various effects of the sliding speed upon the coefficient of friction have been reported. A major portion of the increase in coefficient with rubbing speed is a permanent change and is not reversible; i.e., once a surface of Teflon has been subjected to a high speed, the coefficient normally associated with high speed is obtained even at subsequent slow sliding conditions. Values obtained by various methods are given in Table 2.

The coefficient of friction of Teflon is essentially constant over a wide range of loads. It does increase somewhat at lower loads. A plot of the coefficients obtained at low speeds as a function of the load is given in Fig. 4.

The coefficient of friction of Teflon is constant with temperature over the range from about 80 F to

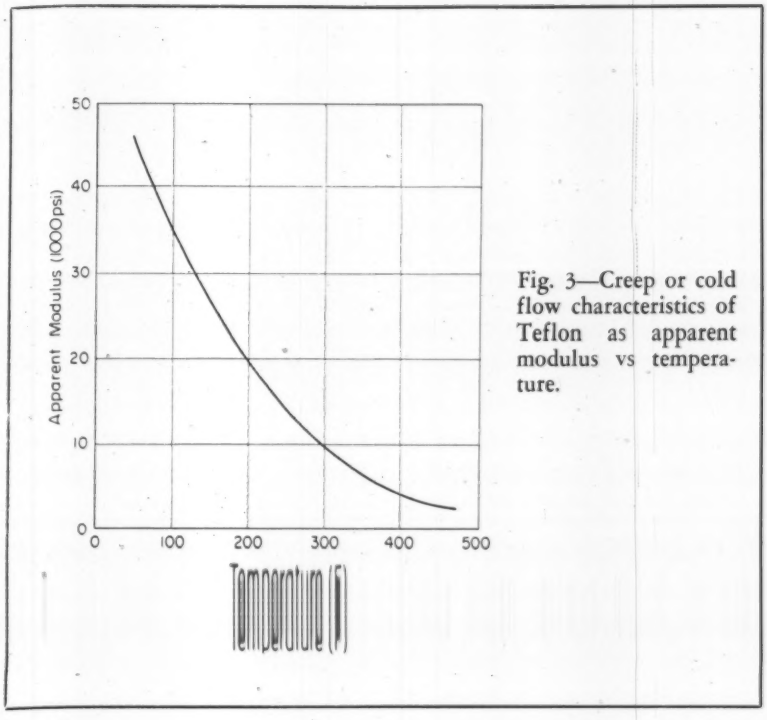


Fig. 3—Creep or cold flow characteristics of Teflon as apparent modulus vs temperature.

its melting point of 620 F. Once the melting point is exceeded, however, the friction doubles.

The effect of external lubricants has been studied by several investigators. Data of Milz and Sargent[1] are given in Table 3. As would be expected, water and oil tend to lower the coefficient of friction and to extend the useful range of these bearings.

Resistance to Wear: All of the desirable frictional properties of tetrafluoroethylene would be meaningless if the parts did not also have good resistance to wear. Under relatively light loads and low speeds, unmodified Teflon is often adequate and is usually used. In severe conditions of load and speed, however, reinforced stocks are employed since these have considerably superior resistance to wear, Table 4.

Any inorganic additives capable of withstanding the temperature required for the curing of Teflon can be used for these applications, although the two more common materials are glass fibers and graphite. These additives increase the coefficient of friction somewhat in proportion to the amount of material added, but the increase is slight. Extremely low coefficients can be obtained, Table 5.

It is important that the surface temperature of the bearing be kept below the melting point, and that only reasonable wear takes place. Some clearance must be maintained under all conditions. It is desirable to have a surface finish of 16 microinches rms.

Load carrying capacity can be estimated from the *PV* ratio where *P* is load in psi and *V* is velocity in ft/min. Unmodified Teflon over a wide range of loads and speeds should be used at *PV* values below 1000, while for the filled compositions it can be as high as 5000. At low speeds it appears that these values can be higher.

Most of the commercial bearings in use today are simple sleeves or thrust washers. Saddle bearings are used in some cases. Ball bearings with alternate balls of Teflon have proved to have unusual properties and are available commercially. The latest development is porous metal bearings impregnated with Teflon. These were developed in England and are now becoming available in this country.

Nylon Plastic

Nylon plastic is being used widely in commercial bearing applications today. Besides several commercial suppliers of stock bearings, many injection molders produce bearings of given dimensions to order. These vary in size from a 1/16-in. inside diameter clock bearing to an 8-in. bearing used in the valve mechanism of a flour-carrying hopper car. Of particular interest are the bearings or gibs on elevator cars. Gibs made of nylon have been used for a number of years—run against dry rails, thus eliminating fire hazard due to lubricant.

Unless otherwise specified, the bearings discussed here are made from the nylon resin tradenamed Zytel 101. This is the same material previously designated FM-10001. Several other compositions are available that in general have the properties of Zytel 101, but have ingredients added for a specific use. Of interest is the heat-stabilized composition, FE-2129. This composition, while still retaining an experimental code, is commercially available and is more heat resistant.

Compositions containing graphite, molybdenum disulfide or other ingredients are on the market today. In general, however, the data on bearing performance are limited so that it is difficult to define the performance to be expected from these various compositions. Certainly the addition of a material like graphite or molybdenum disulfide with a dry coefficient of friction in the neighborhood of 0.1 could help in dry bearings or prolong the useful life of partially lubricated bearings if the additives

Table 3—Effect of Lubricant on Coefficient of Friction*

Lubricant	Teflon-Asbestos (3:1 by weight)	Teflon-Copper (1:1 by weight)
No lubrication...	0.15	0.16
Water	...	0.09
Oil	0.04	0.04

*Data of Milz and Sargent; crossed-cylinder apparatus at 5 lb load and 367 ft/min.

[1]W. C. Milz and L. B. Sargent Jr.—"Frictional Characteristics of Plastics," 10th Annual Meeting, American Society of Lubrication Engineers, Chicago, April, 1955.

are available at the surface as required.

Because of its importance to the dimensional stability of the bearing, all bearings should be stress-relieved to a temperature at least 50 F above the maximum expected. This can be done by heat treating in a suitable oil or other liquid medium. In general, 15 minutes immersion per ⅛-in. of thickness at 300 F is recommended. The temperature can be raised to 350 F if desired.

Stress-relieving (or "annealing") in hot oil guarantees that strains introduced during manufacture will not be present in the finished part. These strains are objectionable in that the parts normally change dimensions—actually contract somewhat—as the strains are relieved. Manufacturing conditions can be selected that do not develop strains. However, it is often more practical, particularly in injection molding, if molding conditions are picked based on other considerations and the part is then given a heat treatment. Additionally, a better product is obtained.

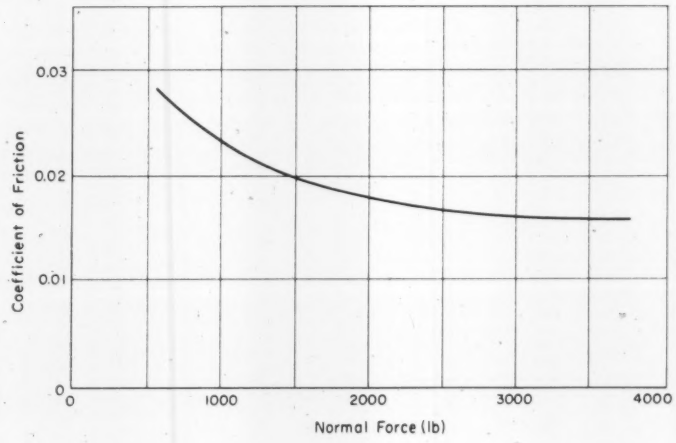


Fig. 4—Frictional characteristics of Teflon as a function of load.

Table 4—Wear Rates of Several Compositions of Teflon

Additive	Wear* (mg/hr)
None	0.74
Glass fibers plus pigment	0.0015
Graphite	0.0015
Copper	0.032
Molybdenum disulfide	0.038

*H. S. White, National Bureau of Standards Report No. 2882, Oct., 1953; bearings ½-in. long by ¼-in. ID, Type 303 stainless steel shafts, 0.002-in. clearance, 2000 psi and 150 rpm.

Table 5—Dynamic Coefficient of Friction of Filled Teflon

Additive	Weight (per cent)	Coefficient of Friction
Very low speed and 1500 psi		
None	0	0.016
Molybdenum disulfide	30	0.026
Graphite	30	0.031
Coke flour	10	0.017
Coke flour	20	0.023
Coke flour	30	0.027
20 ft/min and 120 psi		
None	0	0.26
Glass fiber	25	0.23
Graphite	40	0.19

As an example, considerable data have been obtained in the past on the effect of molding conditions on the inside diameter of nominal 1-in. diameter bearings. While other conditions have some effect on the apparent inside diameter after molding, the most important appears to be the mold temperature, Table 6. As indicated in the last column, however, the actual change of stress-free bearings was considerably less. With higher mold temperatures, even less dimensional change would take place on annealing. While it is possible to vary dimension slightly by a change in molding conditions, the range is limited. In this case, the molder might select a cold mold and possibly a faster cycle or different temperatures on his machine, and then anneal or heat treat the parts.

Basic Properties: Zytel 101 is the highest melting and stiffest of the commercial nylons available today. General properties are given in Table 7. Of particular importance is the coefficient of thermal expansion, since it is several times as large as for the metals often used in bearing applications. Several types of hardness test results are reported for comparison. The values given are for average air exposure, since the moisture content of the material does affect the values.

All nylons are hygroscopic; that is, they will pick up moisture from the surroundings until an equilibrium condition is reached. Since best quality moldings are obtained if the molding powder contains less than 0.3 per cent water, moldings as produced will absorb water. The amounts absorbed and the dimensional changes to expect for several environments are shown in Table 8.

Once these changes have taken place, further change with normal variations in environmental conditions is small. Water diffuses through nylon very slowly. The rate of change in moisture content as it affects the inside diameter of bearings is shown in Fig. 5. Annealed bearings exposed to either 50 per cent relative humidity air, or to water, show a dimensional growth for the first few months. After that, the change is small. Bearings exposed to room conditions for one year with normal variations in relative humidity, after the initial growth, changed less than 0.001-in. per in.

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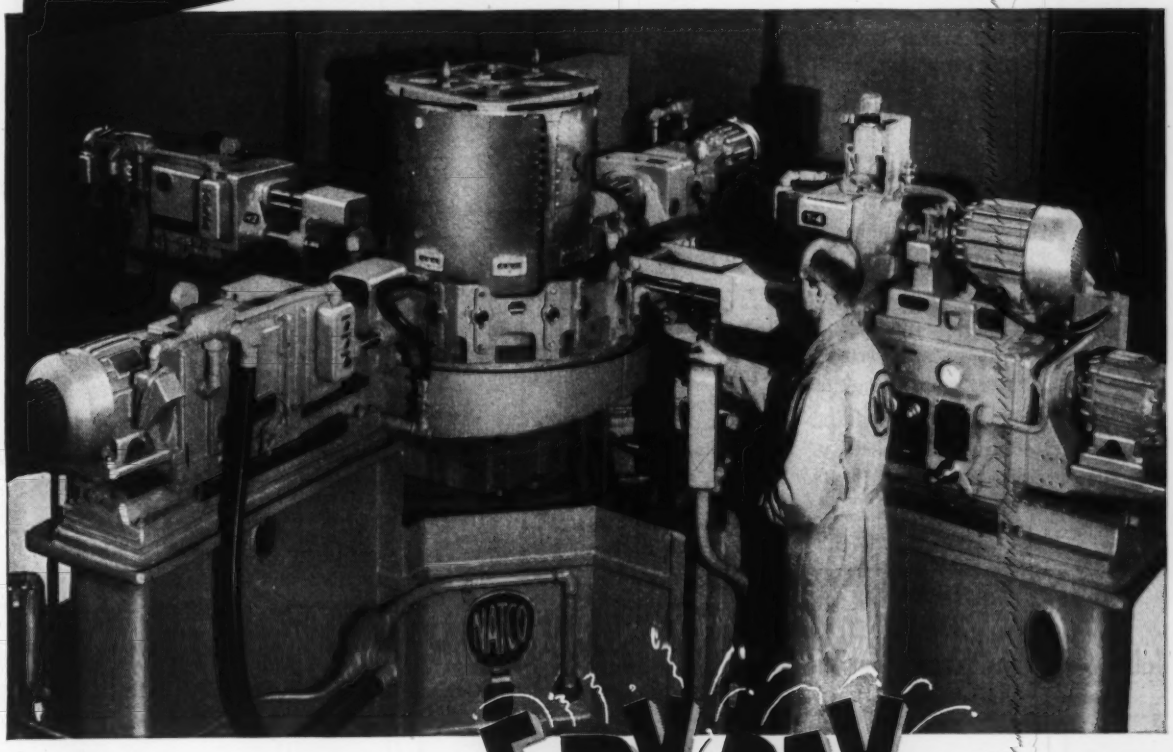

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Strength and stiffness properties also depend upon the moisture content. One of the more important effects of moisture is that it increases impact resistance. The impact resistance of parts conditioned for average air exposure is twice that of the "as-molded" condition. Tensile strength varies with temperature, Table 7. These values are for parts in equilibrium with average air exposures. If saturated with water, strength values 10 per cent lower should be used. Dry parts as molded would have a strength approximately 10 per cent higher at each temperature.

Stiffness or deformation under compressive loads can be calculated from the modulus of elasticity. Modulus is independent of stress up to approximately 3000 psi. Thus, if a bearing with a 0.1-in. wall is under a compressive load of 400 psi, the initial unit deformation at room temperature would be 400 divided by the modulus, 200,000, or 0.002-in. per in. Since the wall is only 0.1-in. thick, the total deformation is 0.0002-in.

Modulus values vary with temperature and moisture content as shown in Fig. 6. Except for parts as molded, the dry values are seldom encountered. For most work, values can be taken safely from the line marked average air exposure —and these will represent the actual values for parts moisture-conditioned to 2.5 per cent water.

Deformation with time while under load—usually called creep or cold flow—should also be consid-

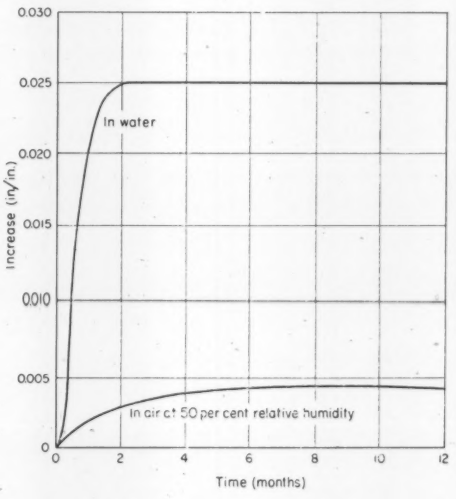

Fig. 5—Change of inside diameter with moisture absorption in a bearing made of Zytel 101 nylon with 1-in. ID and 0.100-in. wall thickness.

Table 6—Dimensional Change in Molded Nylon Bearings*

Mold Temperature (F)	Inside Diameter (in.) As Molded	Inside Diameter (in.) Annealed
70	1.024	1.009
100	1.022	1.009
150	1.020	1.010
200	1.011	1.008

*Zytel 101.

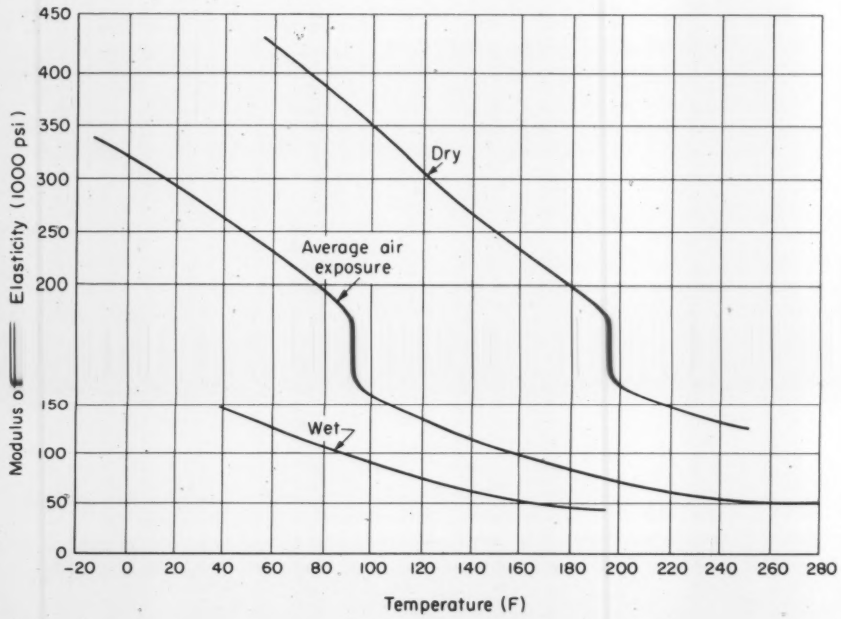

Fig. 6—Effect of environment on modulus of elasticity of Zytel 101 nylon.

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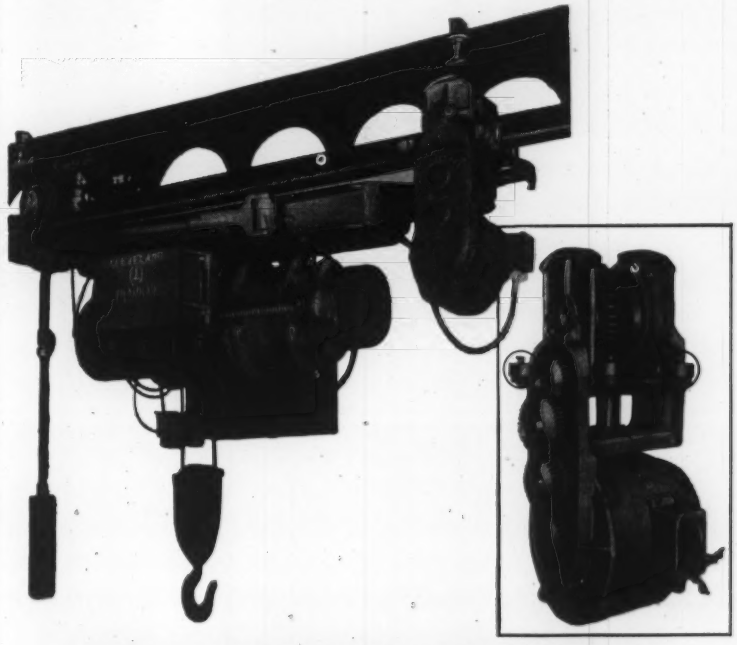

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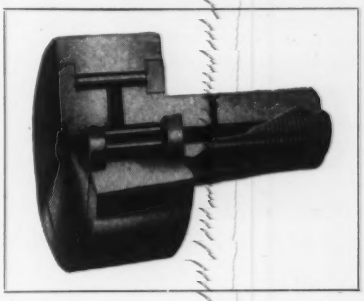

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ered. Parts at room temperature and average moisture content will initially deform 0.009-in. per in. at a stress of 1800 psi or a little over 0.002-in. per in. at 450 psi. With time, if the load is continuously applied, the deformation will continue until it is about twice the initial change in 200 hr. Beyond this time little deformation takes place, Fig. 7.

A simple, yet accurate, method for determining the creep or cold flow is to consider the continued deformation as a change in modulus with time. Thus, from Fig. 6, the initial modulus is 200,000 psi. Yet in approximately 200 hr, the material has deformed as though the modulus were one-half this, or 100,000. This value can be called an apparent modulus.

The value of the apparent modulus as a function of time is shown in Fig. 8. The data are for Zytel 101 at room temperature and containing moisture corresponding to average air exposure. For other environmental conditions, the apparent modulus can be estimated by starting with the appropriate initial modulus on the left and drawing a curve parallel to the one shown.

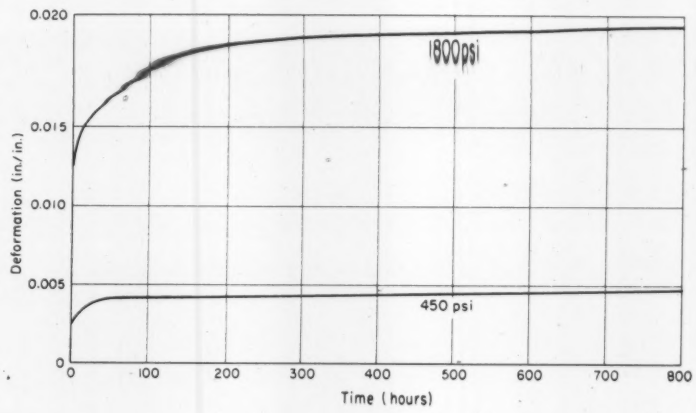

Fig. 7—Effect of long-time compression on Zytel 101 nylon at average air exposure.

For high-temperature applications where long-time exposure to temperatures above 170 F is expected, the heat-stabilized composition FE-2129 should be used. This material retains its properties for over 50,000 hours at 250 F and approximately 2000 hours at 300 F. Otherwise the properties may safely be taken as the same as those shown for Zytel 101.

Various coefficient of friction data for nylon are given in the literature. Since the type of test and the conditions used determines to a large extent the values obtained, comparison between two sources is difficult.

Data obtained with a modified Bowden-Leben type stick-slip machine are shown in Table 9. These results were obtained at very low surface speeds—on the order of ¼-in. per min.

Milz and Sargent[1] concluded that so many factors affected the coefficient of friction that a range should be reported, Table 10. Their data were taken with a cross-cylinder apparatus. The general effect of water and a lubricant is shown. They also reported considerable data on the effect of varying the load and speed.

One difficulty encountered in this work was maintaining proper clearances. As previously explained,

Table 7—Properties of Zytel 101 Nylon Conditioned to Average Air Exposure

Melting point	485 F
Coefficient of thermal expansion	5.5×10^{-6} in./in./deg F
Thermal conductivity	1.7 Btu/hr/sq ft/deg F/in.
Hardness	
Rockwell	118R
Knoop	6.5
Tensile strength	
At −60 F	14,000 psi
At 73 F	9300 psi
At 190 F	6000 psi
Fatigue endurance limit	
At 73 F	3000 psi
At 212 F	2000 psi

Table 8—Moisture Absorption and Dimensional Change in Nylon Bearings*

Environment	Moisture Content (per cent by weight)	Change of Inside Diam (in./in. of diam)
As molded	Less than 0.3	.....
Average air exposure	2.5	+0.006
In water	8.5	+0.025

*Zytel 101.

Table 9—Coefficient of Friction of Nylon

Lubricant	Nylon on Nylon Static	Nylon on Nylon Kinetic	Steel on Nylon Static	Steel on Nylon Kinetic
Dry	0.46	0.37	0.37	0.34
Water	0.52	0.33	0.23	0.19
Ethylene glycol	0.58	0.19	0.20	0.16
Glycerol	0.36	0.19	0.23	0.18
Perfluorolube oil	0.58	0.24	0.30	0.19
Oleic acid	0.29	0.13	0.15	0.08
Polymethyl siloxane DC 500	0.43	0.17	0.19	0.12

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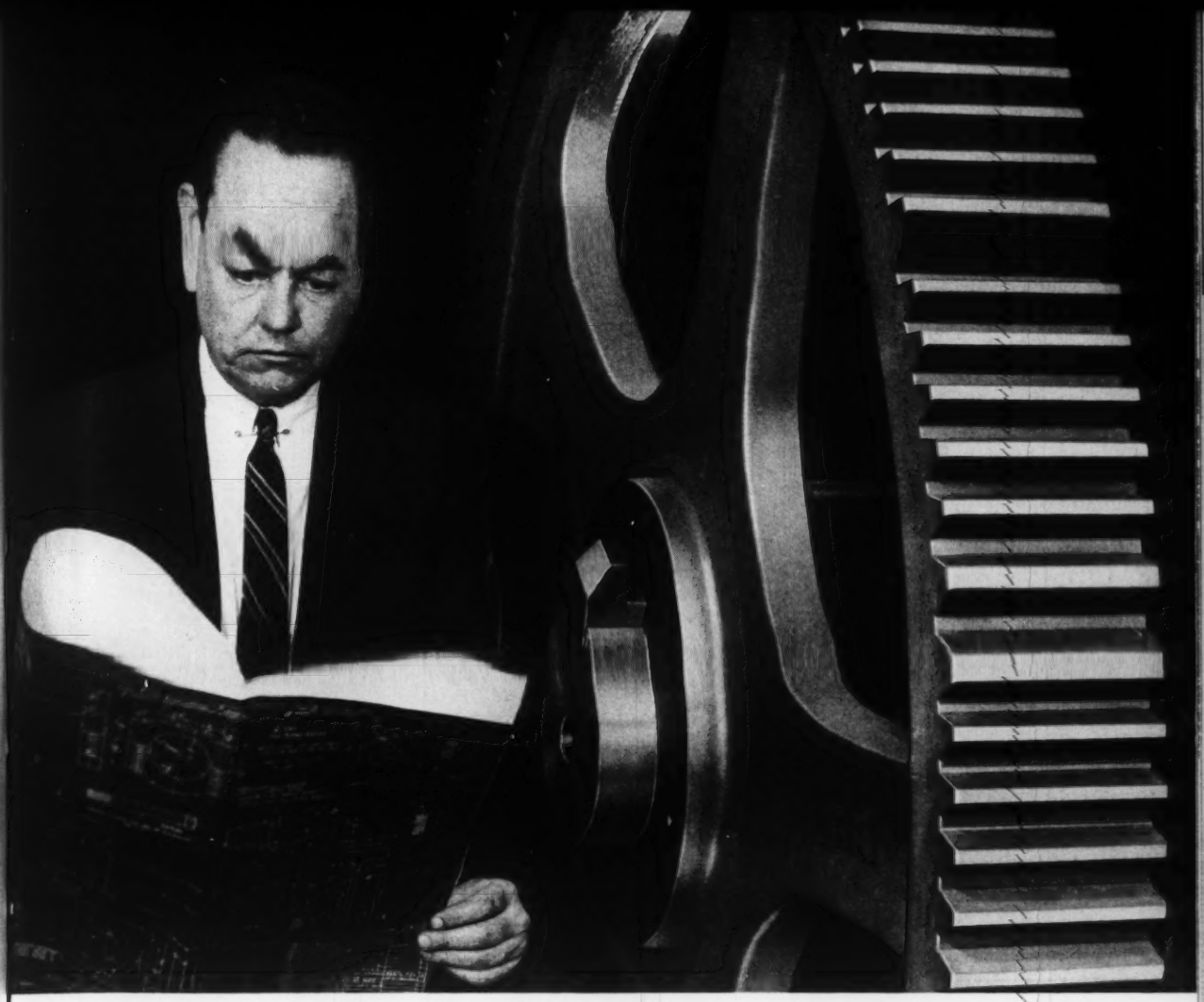

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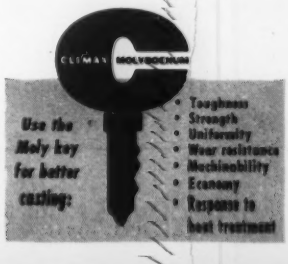


parts of nylon must be sized so that at equilibrium with the service environment the desired dimensions will be obtained. By annealing and moisture conditioning as required inside dimensions can be held to plus or minus 0.001-in. per in. or less if required.

Also of importance is the change in inside diameter due to press fitting the bearing in its holder. For cylindrical bearings with wall thicknesses up to at least ⅛-in., essentially all the interference results in a proportional decrease in the inside diameter. For example, nominal 1-in. diameter bearings with a 0.1-in. wall were pressed into a holder with 0.010-in. interference. The inside diameter decreased 0.008 to 0.010-in.

Properly designed bearings for dry or partially lubricated operation should have a clearance of 0.004 to 0.006-in. for a 1-in. bearing. Larger bearings can have proportionally less clearance.

Operating conditions for these bearings can be estimated from the *PV* values given in Table 11. Since heat seems to be the primary cause of failure, this value can be used for design over a wide range of loads and speeds.

The presence of water will permit increased loads or speeds. One shot of oil or grease increases the permissible range even more.

While the bearings may seize and fail if temperatures become excessive, properly dimensioned bearings can be run with a temperature rise of 100 F or higher if ultimately stable conditions are reached.

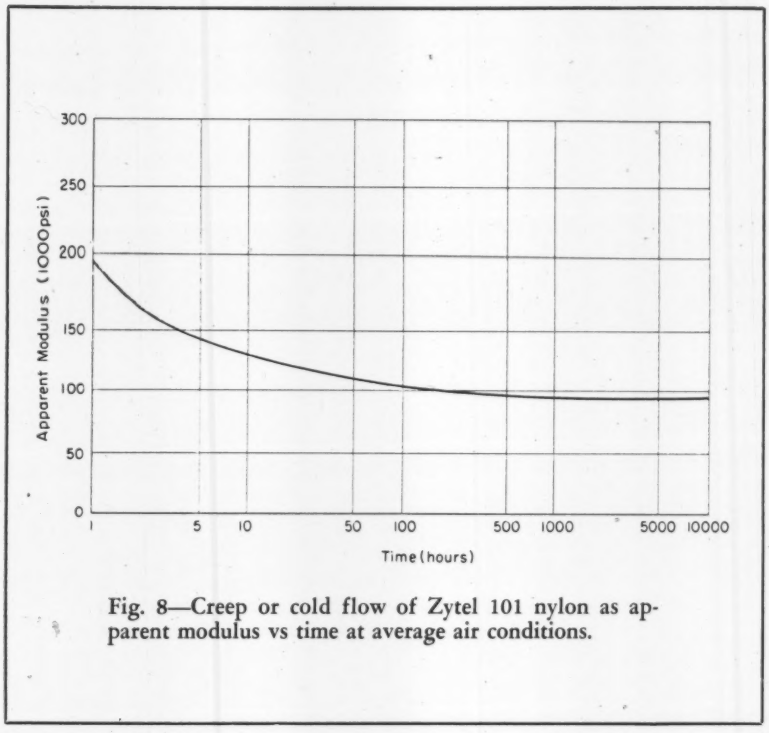


Fig. 8—Creep or cold flow of Zytel 101 nylon as apparent modulus vs time at average air conditions.

Table 10—Spread in Coefficient of Friction Data for Nylon*

Lubricant	Nylon	Nylatron G
No lubricant		
Max	0.33	0.33
Min	0.15	0.22
Water		
Max	0.18	0.21
Min	0.14	0.19
Oil		
Max	0.14	0.13
Min	0.09	0.08

*Applied loads: 1 to 5 lb. Sliding speeds: 8 to 367 ft/min.

Table 11—Safe PV Values for Bearings of Zytel 101

Lubricant	Continuous Operation	Intermittent* Operation
Dry	500–1000	3000
Water	1000–1500	4000
Oil Initially	2000	8000

*Where shaft is in motion approximately one-third of time and continuous operation less than 15 minutes per cycle.

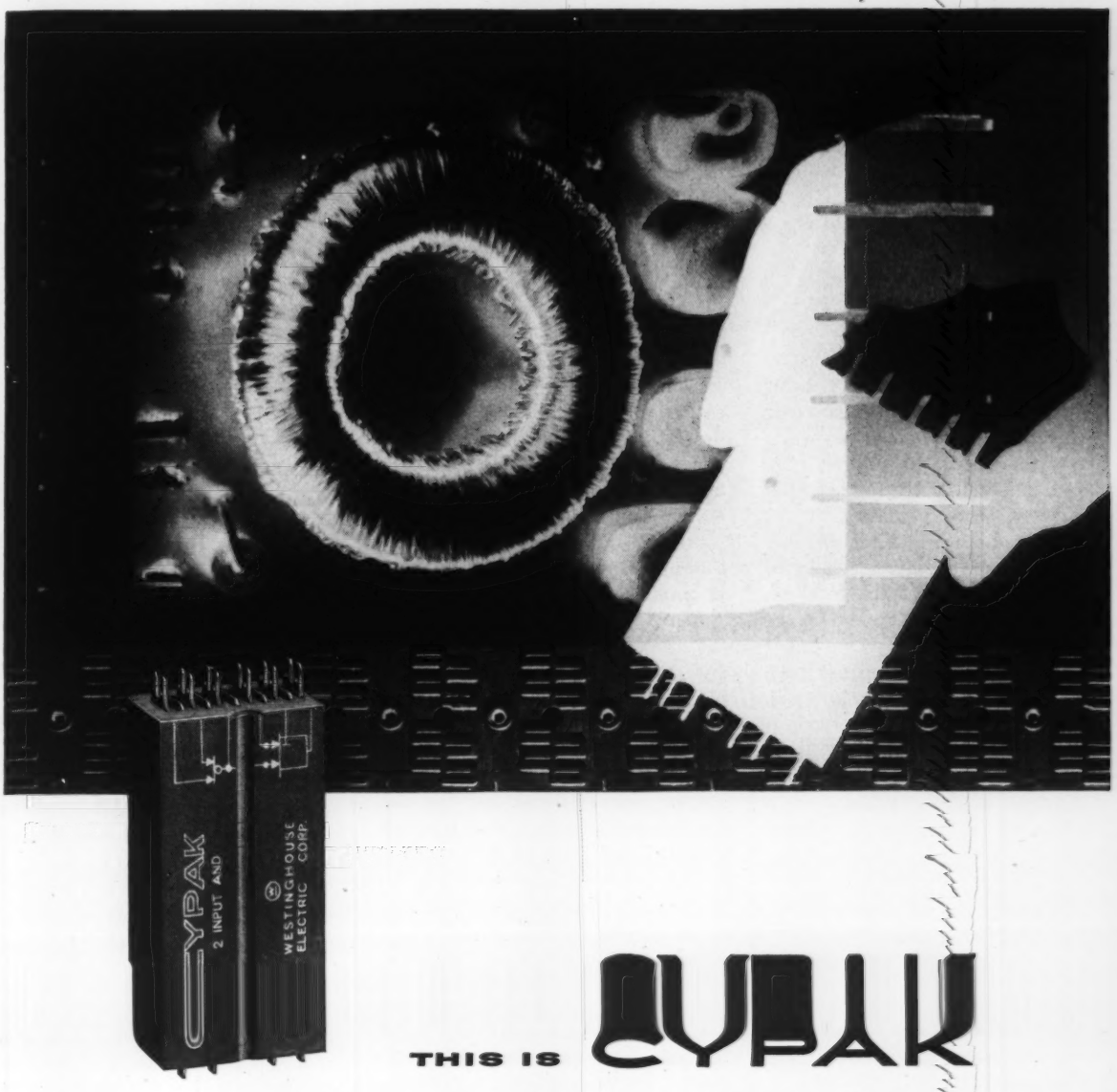
Choosing Nylon or Teflon

Since both nylon and Teflon are used in bearings, the question often arises as to which material should be used. Obviously, each application has to be judged on its own requirements, but some general guides can be established. For example:

1. At room temperature, nylon is much harder, stronger, and more resistant to abrasion and deformation than is Teflon. At elevated temperatures, the reverse is true. If the expected operating temperature is relatively low, nylon is the strong candidate.
2. A second broad guide concerns lubrication. Teflon can be used absolutely dry. Nylon should preferably be given some lubrication. If the part cannot be lubricated, Teflon is often the choice at severe speed conditions, since the coefficient of friction of completely unlubricated nylon is higher than that of PTFE. The top rolls of textile machines illustrate this point well, for nylon is used on the relatively low speed back rolls while Teflon is preferred for the faster front ones.
3. The third and last point involves chemical resistance. Nylon has generally good resistance to most materials and seldom encounters any difficulties on this score. In those cases where severe conditions do exist, Teflon is to be preferred. For instance, it is found on pumps and centrifuges handling acids.

Certainly there have been enough applications developed and now in use commercially to demonstrate that there is a place for partially lubricated or unlubricated bearings of nylon or Teflon.

From a paper entitled "'Zytel' Nylon Resin and 'Teflon' Tetrafluoroethylene Resin as Bearing Materials" presented at the SAE Annual Meeting in Detroit, January, 1956.



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Predicting the outcome for

Inventions in the Courts

By H. R. Mayers
General Patent Counsel
Patent Legal Services
General Electric Co.
New York

A PATENT'S chances of being sustained by the courts can be investigated in one of two ways. First, the patent should be compared in detail with a reasonable sample of other patents that the courts have recently acted on; second, gross probabilities should be evaluated in view of the total recent experience of patents in the courts.

This discussion is confined to a spot check of patents held valid. In examining the first method, it will be noted that the chief guarantee of a favorable outcome for the owner is the possession of a patent that fulfills a recognized need.

For example, one patent covering a feather-plucking machine has been sustained in numerous recent litigations throughout the country. Rubber fingers of special configuration successfully defeather a poultry carcass within 8 to 10 seconds. In spite of arguments attacking the quality of the invention, court after court has been impressed by the machine's ability to perform a function not successfully performed by earlier devices.

In another case, a lower court has recognized invention in a process for making rindless Swiss cheese—a product long sought by the dairy industry. In this cheese-making process, which actually produces a normal rind, the invention appears to be in a curing procedure that reabsorbs the rind into the cheese. The court decision notes that in 1952 the patent owner sold 46-million pounds of the new rindless cheese at a price two to six cents above the market price of conventional Swiss cheese — a factor undoubtedly influencing the decision.

In still another case, the court acknowledged invention in a hypodermic injector that successfully injects a measured dose of medication through the skin by direct projection, without the use of a penetrating needle. A chemical reaction produces a controlled, instantaneous pressure within the structure of the injecting device—a practical result of many previous attempts.

Many other examples indicate that, even in the face of impressive attacks on the inventiveness of patented subject matter, the courts have decided in favor of the patent because of a background of existing demand. Of course, prior failures and the obstacles overcome in taking the last effective step toward real success had to be proved.

Naturally, not all inventions involve solving a recognized problem. Sometimes, technical advance necessarily depends on recognizing either the existence of a problem or a potential for improvement. When a patent owner can clearly show one of these qualifications, his chances for a favorable outcome are good.

One case impressively illustrating such a situation brought successful litigation against a major industrial company. The patent owner's invention appeared to reside in merely changing the angle of attack of the cutting blade of a particular milling machine. In its earlier versions the machine was considered satisfactory for most purposes. Thus the need for and possibility of its further improvement were not issues until this patentee, either by insight or experimentation, discovered that a better than 100 per cent increase in cutting speed could be accomplished by his adaptation.

A lower court's recent validation of appearance-design patents covering new shapes of chocolate candies illustrates a different application of the power of this principle. Here the inventor, or patentee, conceived of chocolate miniature animals that would enhance candy sales appeal—a conception verified by experience. Clearly impressed by the impact that the patentee's contribution had made on candy sales, a court rebuffed the defendant, who relied on the unlikelihood of invention being found in a chocolate animal's shape.

Infringer's Conduct: The background of the invention is not the only guide that the courts look to in determining the outcome of litigation.

The prior actions of the defendant—the party charged to be an infringer—may predetermine the court's approach, as in a recent case in the soap and cosmetics industry. It involved shaving lather generated by gas pressure from a can containing soap solution plus a compressed gas of suitable characteristics. A patent on one version of this product was held valid and infringed, in spite of strenuous arguments as to its inherent obviousness in view of prior insecticide spray devices and the like. However, the defendant company had apparently filed patent applications claiming invention in closely similar subject matter and also decrying the effectiveness of the prior art sought to be relied on in litigation—a circumstance the court thought contradictory to arguments made during the lawsuit.

Again, a defendant may contribute to his downfall by too closely or too promptly copying another patentee's minor technical advance. Take, for example, a situation that involved a patent covering a seemingly straight-forward change in vacuum-cleaner design: all the design elements were shown to be

Facing Page—ITEM 586→

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used in previously patented applications. The court found the patent valid and infringed, despite the formidable defenses marshaled against it because of evidence of the defendant's intimate relationship to the patentee and his prompt adoption of the inventor's ideas.

Thus, close attention to background considerations and collateral circumstances is at least as important as narrow technicalities in forecasting results of patent litigation.

Statistical Approach: Few patents can be brought before the Supreme Court of the United States, but the initially defeated party in patent litigation can usually have his case reviewed by one of the 10 Circuit Courts of Appeals. Therefore, the action of these courts effectively determines the climate in which patents are tested and held to be valid or invalid. Statistics indicate a colder climate today: from 1925 to 1930, 50 per cent of the patents tested at the appeal level were sustained as valid, while approximately 25 per cent are currently being sustained.

In 1930, the patent owner had a one-in-two chance of success in the typical patent litigation. Thus, the prudent operator might have been justified in bringing suit if, in the event of winning, his prospective recovery from the infringer was at least twice the litigation cost. Of course, it would have been appropriate to consider not only the prospective recovery from the immediate infringer but also potential recoveries from other infringers whose willingness to come to terms might be favorably influenced by a successful court action. Presumably based on these considerations, a relatively large number of patents were brought to court during the 1920's.

Today's one-in-four prospect of success demands an expected recovery of at least four times the litigation cost. Obviously, the chances of such recoveries are much slimmer. Therefore, the number of cases brought into court should be less under 1955 conditions than those of 1925.

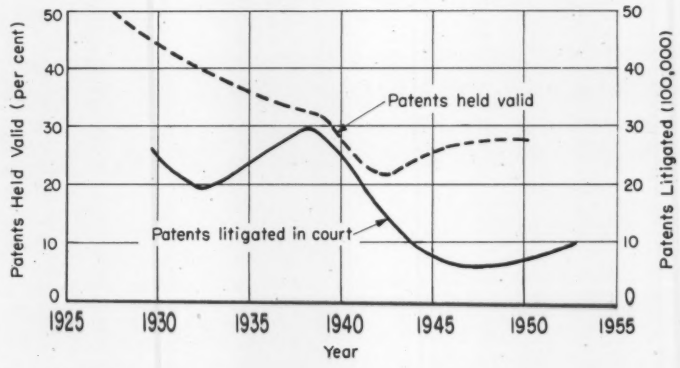


Fig. 1 — Patents litigated in U. S. Circuit Courts of Appeals.

The facts verify this assumption, Fig. 1. The downward trend in number of patents brought before the courts correlates with the changing chances of success. Displacement of the two curves (abscissa) suggests that the public requires a five-year time lag to recognize and assimilate the impact of the last five years of court decisions. Presumably, the depression years and World War II account for the erratic behavior of the litigation curve from 1935 to 1945.

From "Inventions in the Courts" in General Electric Review, *May-July*, 1956.

Designing for Low Cost

SOME good rules to follow in designing for low cost are as follows:

1. Design for maximum simplicity of all functional characteristics and sturdiness required in the end product.

2. Ask yourself, "Is it absolutely required?" If possible, eliminate the part or consolidate it with others.

3. Design for most economical production method consistent with quality and quantity of output required.

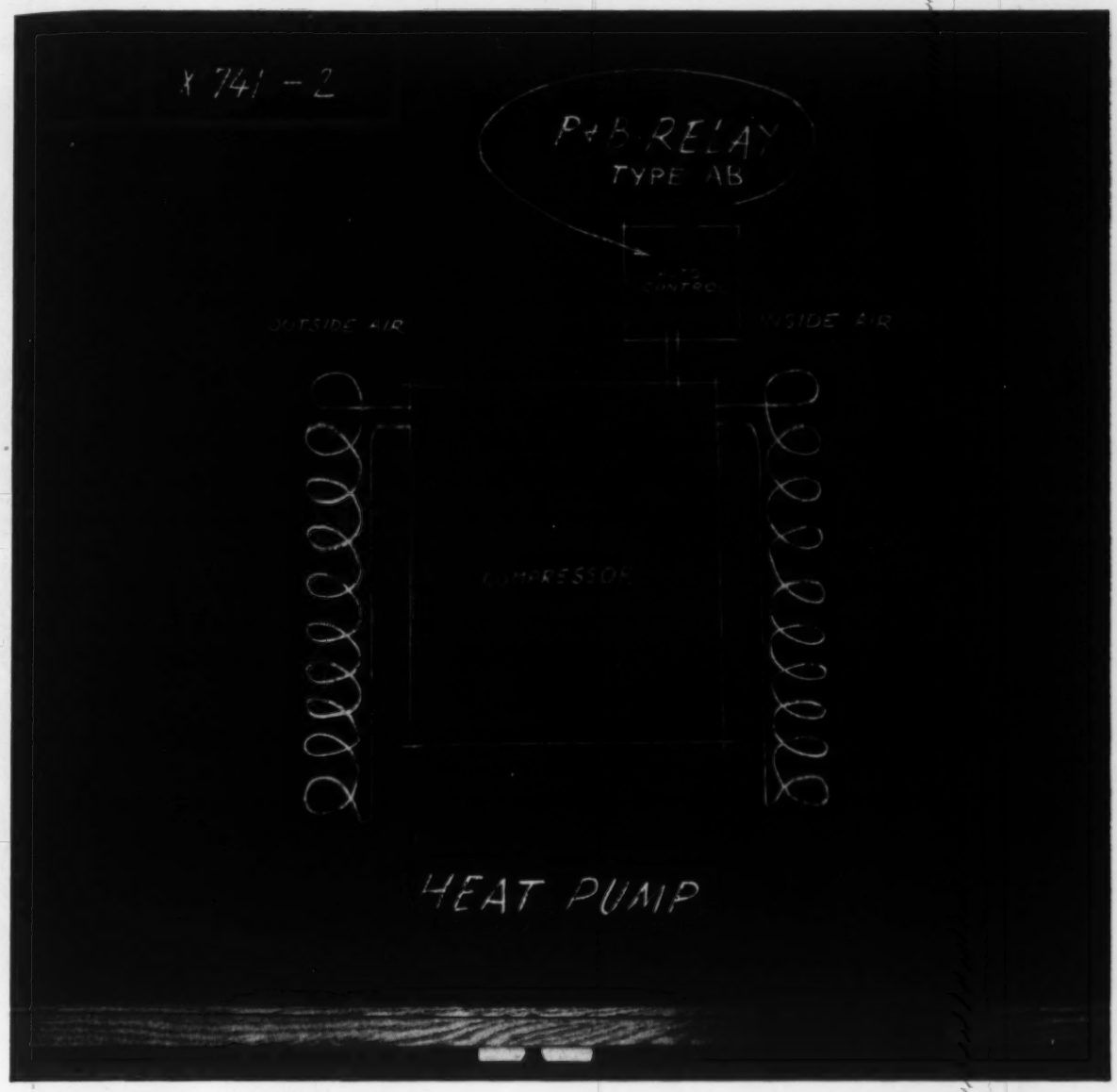
4. Select the lowest-cost material which will fit the foregoing requirements.

5. Design for minimum finishing operations.

6. Design for ease of holding and setting up or handling the parts.

7. Specify finish and accuracy to no greater tolerances than are necessary.

From a paper by Kenneth L. Block entitled "How to Improve Profits—a Challenge to Engineering," presented at the 1955 *prize-paper contest for younger mechanical engineers conducted by Chicago Section of ASME.*



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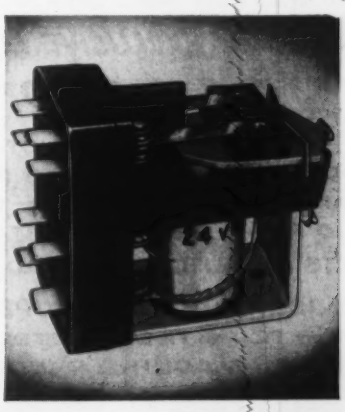

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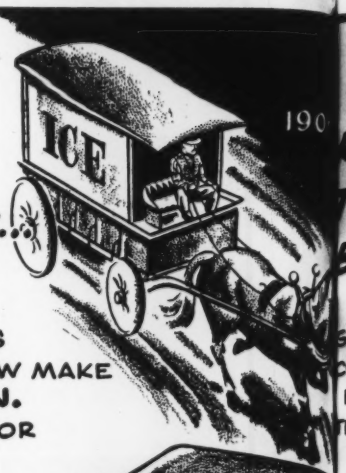

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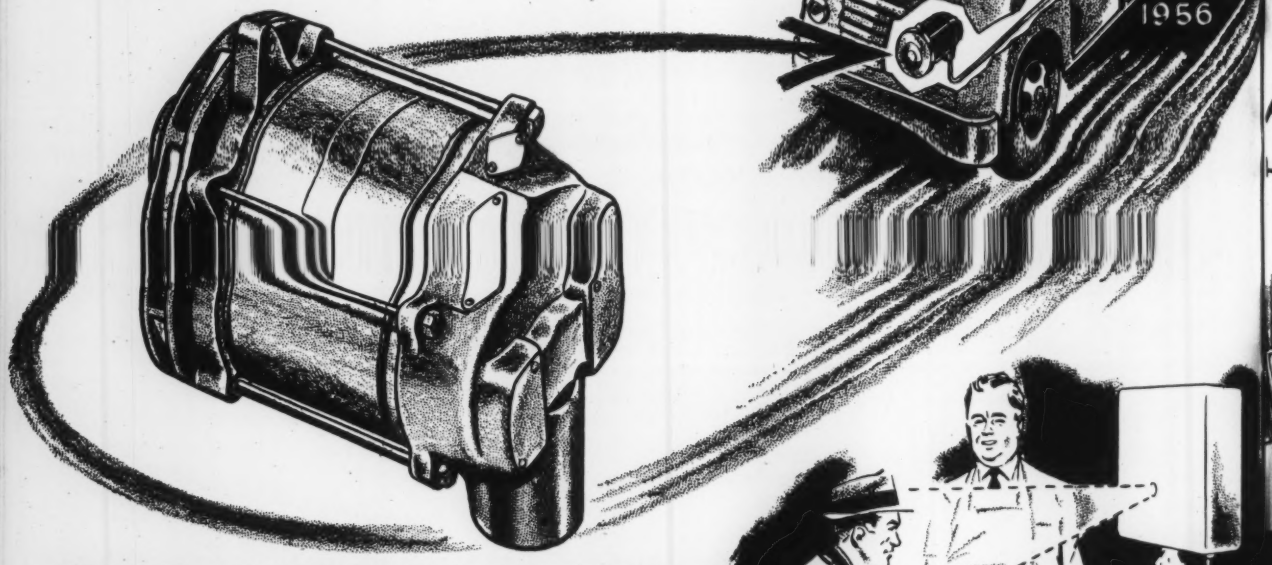

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HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Laminated Forming Material

Uses of S-52 laminated plastic forming material are described in illustrated form 604. Lightweight material is used for stretch forming, metal spinning and forming dies. Its qualities, including easy machinability and toughness, are given. 4 pages. Formica Co.

—Circle ITEM 401

Process Cast Iron

Entitled "Precision Cast Irons", illustrated bulletin contains check list of both mechanical properties and tested applications of this line of six metallurgically controlled irons. The SorboMat metallurgical system is used. 20 pages. McNally Pittsburg Foundries, Inc.

—Circle ITEM 402

Automation Cylinders

Heavy duty air cylinders for automation applications on conveyors, machine tools, presses and other equipment are subject of illustrated bulletin. Five types of mountings for cylinders with bore sizes from 1½ to 6 in. are covered. 1 page. S-P Mfg. Corp.

—Circle ITEM 403

Precision Casting Process

Details of the Glascast precision casting process are contained in bulletin GC-2. Booklet explains how Glascast powder is made into shock-resistant, precision mold for casting high melting point alloys. All procedures are presented. 20 pages. Corning Glass Works.

—Circle ITEM 404

Flange Ball Bearings

Bulletin SS-125 deals with design considerations and dimensions on line of two-bolt Sealmaster ball bearing units for shafts ranging in diameter up to 2 13/16 in. 2 pages. Stephens-Adamson Mfg. Co., Sealmaster Bearings Div.

—Circle ITEM 405

Corrosionproof Seals

A complete line of chemically inert mechanical seals for equipment handling acids, corrosives, solvents and gases is described in bulletin S-205-2. Sealing members are fabricated of Teflon which withstands operating temperatures ranging up to 500°F. Sectional views show design. 8 pages. Crane Packing Co.

—Circle ITEM 406

Heat-Detector Cells

Radiations ranging from a rabbit hiding in the brush to the blast of an open furnace can be detected with Servotherm thermistor heat detector cells. At a distance and throughout a wide temperature range, these cells speedily detect and accurately report such radiations. Three models are described in illustrated brochure. 4 pages. Servo Corp. of America.

—Circle ITEM 407

Rotary Swaging Machines

A redesigned line of rotary swaging machines is introduced in illustrated bulletin. Various models handle solid work ranging in diameter from 1/16 to 1 in. and tubes from ¼ to 2½-in. diameter. 4 pages. Torrington Co., Swaging Machine Div.

—Circle ITEM 408

Plastic Insulating Material

Technical brochure on "Haysite," a glass reinforced alkyd base polyester insulating material, contains a characteristics chart, comparison charts and information on applications. 12 pages. Hays Mfg. Co., Reinforced Plastics Div.

—Circle ITEM 409

Plastic Laminate Lining

A new lining material that can be applied to containers, tanks and pipes is subject of bulletin AD 152. Material is a laminate of Kel-F plastic fused and flowed into a glass fiber cloth backing. 2 pages. Garlock Packing Co.

—Circle ITEM 410

Air & Hydraulic Hose Products

Easily read, illustrated catalog 200 covers low, medium and high pressure hoses for air, water, fuel, lube and hydraulic applications. special hoses for steam, LP-gas, Freon and fire-resistant hydraulic fluids; as well as detachable, reusable fitting and couplings. 64 pages. Aeroquip Corp.

—Circle ITEM 411

Ceramic Insulating Bushings

Specifications on center shoulder bushings, insulating washers and bushings and insulating shoulder bushings are contained in revised catalog sheets 400, 600 and 700. These standard parts are made of Lavolin, a steatite ceramic for high temperature insulation with high dielectric and mechanical strength. Star Porcelain Co.

—Circle ITEM 412

Finned Tubing

How and where Trufin finned heat exchanger and condenser tubing is being used throughout industry is related in Process Flowsheet booklet. Tubing has integral fins squeezed directly for the tube wall which give it 2½ times greater heat transfer surface than prime surface tube. Calumet & Hecla, Inc., Wolverine Tube Div.

—Circle ITEM 413

Torque Converters

"The trend is to torque converters in the construction industry," according to feature story in latest issue of "Production Road." Timely tips on efficient power transmission to all powered equipment users are given. 20 pages. Twin Disc Clutch Co.

—Circle ITEM 414

Self-Aligning Bearings

Series S adjustable single-row self-aligning roller bearings, series D adjustable double-row bearings and series M preadjusted double-row self-aligning bearings are described in booklet 2658. Dimensions and recommended fitting practices are included. 8 pages. Link-Belt Co.

—Circle ITEM 415

O-Ring Seals

Cross reference charts of size numbers with dimensional data for all Parker O-ring seals are contained in catalog 5701. A total of 296 standard O-ring sizes are offered. It includes condensed charts of standard synthetic rubber compounds. 12 pages.

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Helpful Literature

Parker Appliance Co., Rubber Products Div.

—Circle ITEM 416

Sintered Bearing Alloys

Design requirements, metallurgical qualities and alloy selection data on Gramix sintered metal bearings for various applications are discussed in engineering bulletin No. 18. Types and grades are described for every bearing requirement. 6 pages. United States Graphite Co.

—Circle ITEM 417

Vinyl Foam

Application ideas for Rubatex vinyl foam are presented in booklet "See What It Can Do for Your Product." Foam is available in white, blue, green, red, yellow and pink as well as specified colors. 24 pages. Great American Industries, Inc., Rubatex Div.

—Circle ITEM 418

Steel Casting Process

Ceramicast, a new process for producing close tolerance steel castings from ceramic molds is described in bulletin. Several major applications are illustrated, and advantages of quality, cost and versatility are discussed. 4-pages. Lebanon Steel Foundry.

—Circle ITEM 419

Nickel-Free Stainless Sheet

Illustrated booklet describes price advantage, physical properties and analysis, relative corrosion resistance, fabrication, application and care of MicroRold type 430 nickel-free stainless steel sheet. 16 pages. Washington Steel Corp.

—Circle ITEM 420

Elastomer Properties

Kel-F elastomer, a fluorocarbon rubber with high resistance to heat and corrosion, is subject of companion bulletins which deal with its properties, applications, compounding and fabrication. It is usable for hose, tubing, gaskets, diaphragms, seals and tank linings, and in insulation, clothing, paints and sealants. 16 pages. M. W. Kellogg Co.

—Circle ITEM 421

Electronic Instruments

Dynamaster electronic potentiometer and bridge instruments for recording and controlling are described in bulletin P1245A. Specifications are given for various sizes and types of air and electric control models as well as for such accessories as resistance bulbs, magnetos, photocells,

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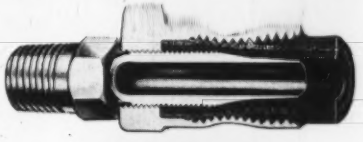
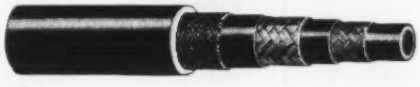
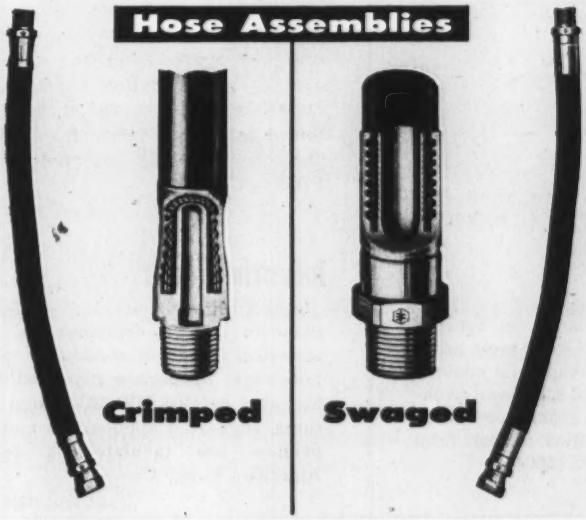


Bulk Hose



Hose Assemblies



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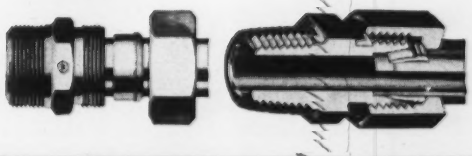
ERMETO



SAE 37° FLARE

3-PIECE

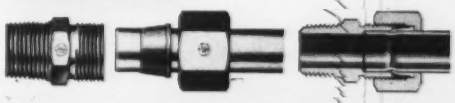
2-PIECE

SAE 45° FLARE

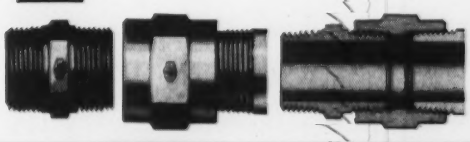
INVERTED FLARE

COMPRESSION

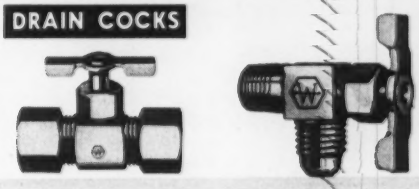
SELFALIGN



PIPE



DRAIN COCKS



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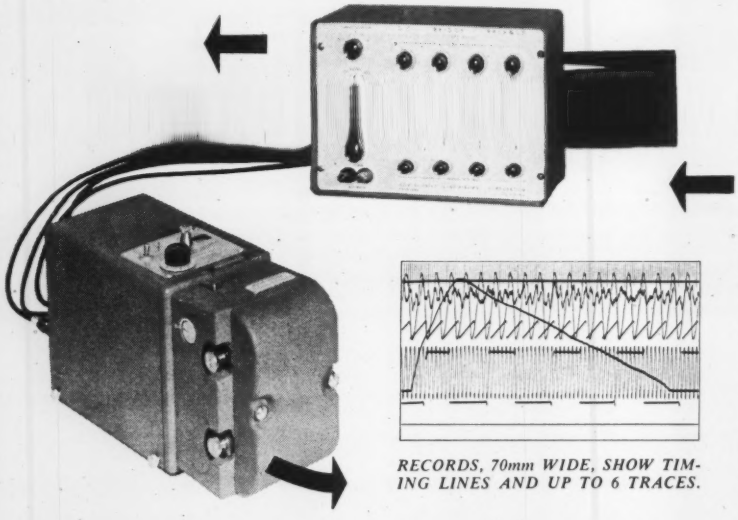
—ITEM 591—

new high in performance

new low in cost

This combination of Consolidated's 6-channel 5-117 Recording Oscillograph and 8-110 Bridge Balance fills the long-standing gap between pen-type recorders and complex oscillograph/amplifier systems . . . provides high-speed, graphic records of physical phenomena invaluable in research and development, product analysis, and clinical diagnosis. Stress, strain, vibration, pressure, temperature . . . measure them all at the same time for a *true picture* of either a product or a patient. The system is so simple to operate that no special electronic experience is needed . . . and so light that it can be carried anywhere. You'll find dozens of applications for it in your laboratory, your plant, or your clinic.

A COMPLETE RECORDING SYSTEM FOR DYNAMIC TESTING



RECORDS, 70mm WIDE, SHOW TIMING LINES AND UP TO 6 TRACES.

5-117 Recording Oscillograph . . . records up to 6 channels of data *without amplifiers* at frequencies to 200 cps (with amplifiers, to 3000 cps). Uses 70-mm by 100-ft paper or film, driven ¾" to 24"/sec. Timing lines appear every 1/100 second. Bulletin CEC 1533B-X2.

8-110 Strain-Gage Bridge Balance . . . 4-channel control link between oscillograph and strain gages or resistance-type pickups. Has controls for balancing and adjusting d-c voltage across each channel and provision for calibration resistor. Send for Bulletin CEC 1560-X9.

Consolidated Electrodynamics
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formerly Consolidated Engineering Corporation
300 North Sierra Madre Villa, Pasadena, California
ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL
Sales and Service Offices in: Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.

—ITEM 592—

Helpful Literature

conductivity cells and frequency converters. 64 pages. Bristol Co.

—Circle ITEM 422

Self-Aligning Bearings

Specifications and other data on Shafer self-aligning roller bearings for shaft sizes from ¾ to 7 in. are presented in catalog No. 55. Concave bearing rollers run between convex raceways. Revised engineering data and new load rating tables are included. 72 pages. Chain Belt Co.

—Circle ITEM 423

Cold-Forging Method

The Kaufman cold-forming double-extrusion process which allows upsetting of metal for the head of a cap screw at the same time shank diameter is extruded is described in folder "This Is the Kaufman Process." 4 pages. Cleveland Cap Screw Co.

—Circle ITEM 424

Metallized Ceramic Coating

Molcote, a metal-to-ceramic coating which presents a surface to which metal or other metallized ceramic parts can be hard soldered up to 2200° F, is discussed in bulletin 1155. Solder bonds, strong to the point of fracture of the ceramic, are also described. 4 pages. Frenchtown Porcelain Co.

—Circle ITEM 425

Bonded Rubber Parts

Written for design and material engineers, illustrated bulletin "Apcotite" discusses the bonding of natural and synthetic rubber and silicone to metal. Rating chart shows materials that can be successfully joined to various polymers. Applications are shown. 8 pages. Acushnet Process Co.

—Circle ITEM 426

Industrial Wheels

Specifications on 128 different Steelrite wheel combinations and semisteel, pressed steel and semipneumatic wheels are contained in illustrated catalog HW-56. Design features, suggested applications and capacities are tabulated. 4 pages. American Pulley Co.

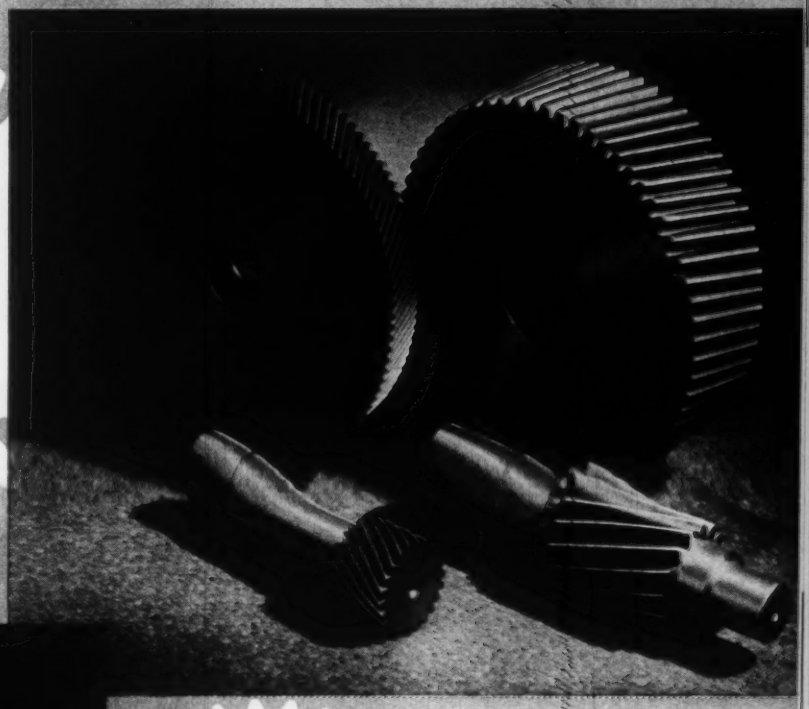
—Circle ITEM 427

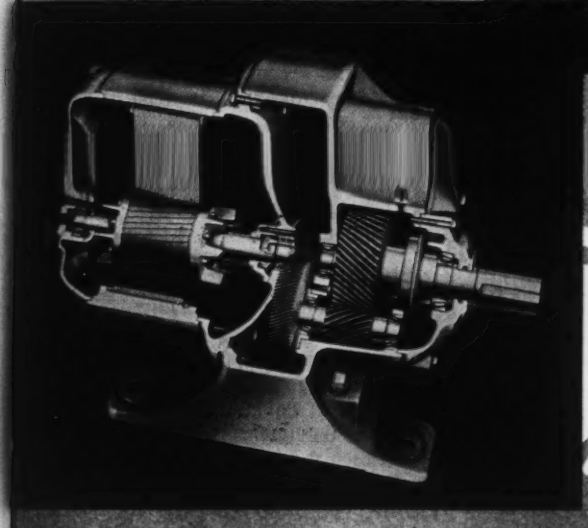
O-Rings & Custom Moldings

Engineering Handbook No. 525 contains data on O-ring seal design and internal and external grooves, and details of gland finishes, chamfers, gland selection, piston rods, and cylinder materials and lubrication. Sections deal with silicone rubber

GEARS *match Motor Reliability*

Both Gearing and Motor of the **SYNCROGEAR** are "Custom-built" by **U. S.** to the same high quality



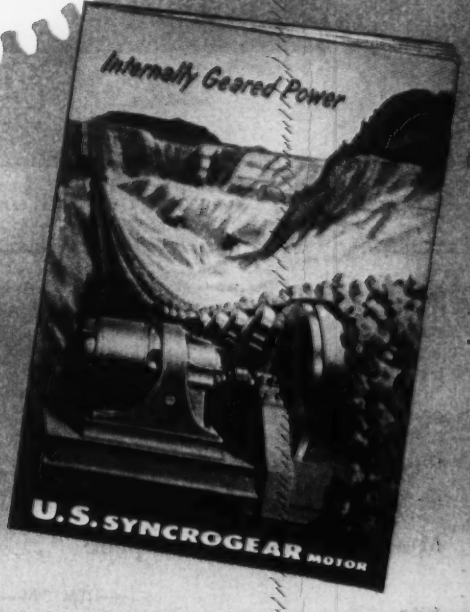


U. S. SYNCROGEARS have a proven record of dependable service with longest life under rugged conditions...

The Mighty

U. S. SYNCROGEAR MOTOR

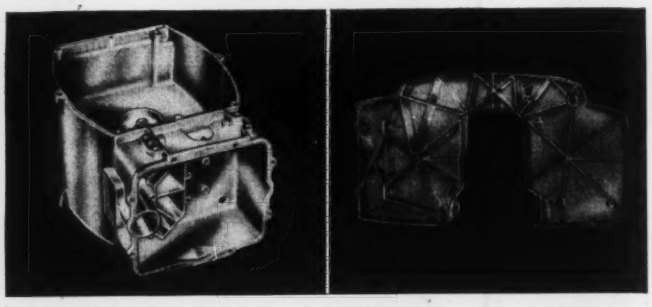
Completely described and illustrated in our new 16-page full-color brochure. Learn about new techniques in gear making for gear motors. In addition to custom-engineered gears, U. S. Syncrogear motors incorporate many other advanced life-lengthening features, including: genuine pyramidal design; completely enclosed case; solid shank ever-tight pinion; friction-free oil seal; asbestos-protected windings; normalized castings and Lubriflush transverse lubrication.



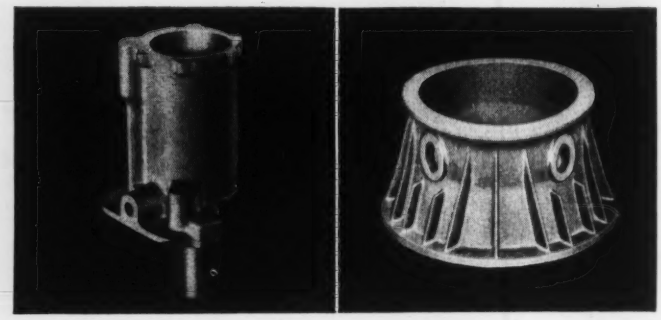
U.S. *Electrical* MOTORS

P.O. Box 2058, Los Angeles 54, Calif., or Milford, Conn.

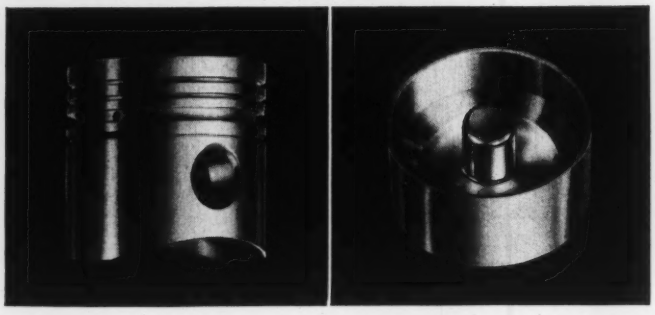
for die castings



...permanent mold castings



...impact extrusions



Regardless of your product, if you use castings or impact extrusions, Thompson's experienced and creative engineers can show you where and how to simplify your operations and save on costs. Let us quote now on your plans. Just write, wire or phone Dept. MD-6, Light Metals Division, Thompson Products, Inc., 2269 Ashland Road, Cleveland 3, Ohio, HEnderson 1-6765.

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2269 Ashland Road • Cleveland 3, Ohio

Helpful Literature

products, custom molding, and engineering tables. Plastic & Rubber Products Co.

—Circle ITEM 428

Electric Motor Components

Charts showing internal and external thread brush caps and brush holders, and molded commutators are included in illustrated bulletin "Stock Sizes." Design reference material is given on units for makers of motors and motor-operated units. 12 pages. Midwest Molding & Mfg. Co.

—Circle ITEM 429

Small Motors & Blowers

Fractional horsepower electric motors, including permanent split capacitor, shaded pole and series or shunt types, are detailed in Micro-Motor catalog RB-400. Also described are integral motor-driven blowers for supplying up to 350 cfm of free air. 12 pages. Redmond Co.

—Circle ITEM 430

Spot Welding Fasteners

Stock pin, screw and nut fasteners for spot welding to equipment and components are detailed in illustrated bulletin 561. Typical applications of these devices are shown, and specifications are given. 4 pages. Ohio Nut & Bolt Co.

—Circle ITEM 431

Compressible-Liquid Springs

Designed to replace coil springs in die and other applications, Taylor Liquid Springs utilize compressibility of a special liquid to obtain action. They are built with forces from 200 to 125,000 lb in 2½ to 8-in. lengths. Data are given in catalog LS. 4 pages. Taylor Devices Inc.

—Circle ITEM 432

Semipneumatic Wheels

Written for original equipment manufacturers, catalog 401 contains design information on line of semipneumatic-tired wheels with flanged oilless or ball bearings. Standard and heavy duty types are for use on all types of mobile or portable equipment. 4 pages. Gleason Corp.

—Circle ITEM 433

Small Precision Bearings

Information on antifriction bearings for special applications is presented in catalog AFB-1. Dimensions and load ratings are given for single and double row, deep groove radial and angular contact bearings. Designs for high and low temperatures,

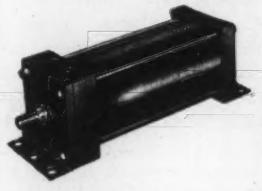
RIVETT FURNISHES A

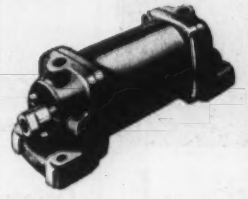
complete POWER PACKAGE!

Get all your air and hydraulic needs from one source!

Over 500 standard models in all sizes for immediate delivery!

AIR CYLINDERS—168 Models





TIE ROD DESIGN

150 P.S.I. air; 250, 350, 500 P.S.I. oil. 8 mountings; 10 bore diameters; single or double end rod; internal or external thread; cushioning. J.I.C. Special covers. See Catalog 10.

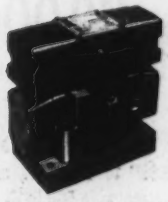
KEEPER RING DESIGN

150 P.S.I. air; 300 P.S.I. oil. 7 mountings; 9 bore diameters; single or double end rod; internal or external thread; cushioning. Special covers. See Catalog 55.

HYDRAULIC VALVES—200 Models

Panel Mounted
Pipe Mounted
Direct Control
Functional

Pipe Mounted Foot

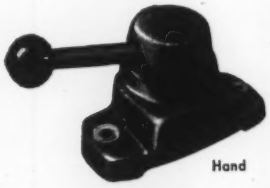


Panel Mounted Solenoid

1500 and 3000 P.S.I. Standard, spring-return, spring-centered, ball detent. All piston designs. Hand, foot, cam, solenoid, solenoid pilot, oil pilot, air pilot. ¼", ⅜", ½", ¾", 1", 1¼", 1½", 2". See Catalog 204.

Panel valves conform to J.I.C. Greater flow; low pressure; shock resistant. Interchangeable sizes. See Catalog 261.

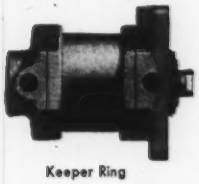
AIR VALVES—47 Models



Hand

150 P.S.I. 3 and 4-way. Hand, foot, cam, solenoid, and pilot. ¼", ⅜", ½", ¾" and 1". Pilot valves in side and foot mountings—palm, push-button, cam, foot, solenoid operation. See Catalog 303.

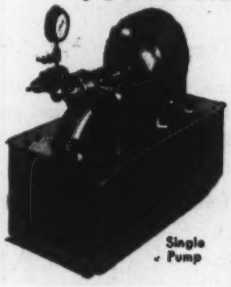
HYDRAULIC CYLINDERS—108 Models



Keeper Ring

300 and 1500 P.S.I.; 3000 P.S.I. furnished. 7 mountings; 10 bore diameters; standard and 2:1 over-size rod: single and double end rods, internal or external thread; cushioning. Special covers. See Catalog 106.

POWER UNITS—17 Models



Single Pump

1000 and 1500 P.S.I. Single pumps in six tank sizes. Capacities .4 to 40 G.P.M. Double pumps in four tank sizes with combined capacities 3.5 to 80 G.P.M.

CUSTOM-BUILT

Pressures to 5000 P.S.I. For unusual space, size, piping, valving, mounting, operation. See Catalog 400.

HANDY AIDS FOR AIR & HYDRAULIC CIRCUITS!

90 pages of working drawings, specifications, cut-away views. Get Free Copies Today!

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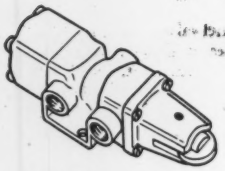
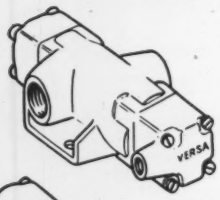
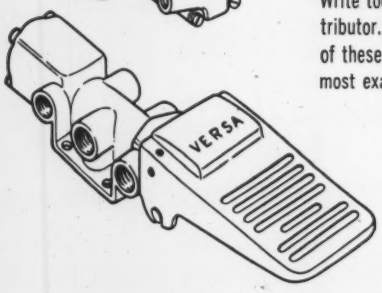
—ITEM 595—

in Over 110,000 Variations!







Versa Valves are available in 2-, 3-, 4-, and 5-way types with over 20 actuating devices, in sizes from ⅛" to 1" N.P.T., and for pressures from partial vacuum to 500 PSIG.

The entire line of Versa Valves (over 110,000 variations) are stocked by authorized Versa distributors, strategically located throughout the United States and Canada.

All Versa Valves are triple pressure and functionally tested under water for guaranteed leakproofness . . . actually exceed J.I.C. standards.

Write today for the name of your nearest Versa distributor. Remember, you can get immediate delivery of these rugged, compact control valves to fit your most exacting hydraulic or pneumatic requirement.

The entire line of VERSA Valves is explained in our new comprehensive Folder #14

VERSA

VERSA PRODUCTS COMPANY INC.
247 SCHOLES STREET
BROOKLYN 6, N. Y.

Helpful Literature

corrosive service and applications needing nonmagnetic properties are discussed. 32 pages. Industrial Tectonics, Inc.

—Circle ITEM 434

Electric Fan Clutches

Thorough analysis of the features and operating advantages of custom-engineered fan clutches for internal combustion engines on trucks, machinery and stationary equipment is presented in illustrated manual 6214. Operation and methods of control are described. Test reports show actual savings in horsepower. 18 pages. Warner Electric Brake & Clutch Co.

—Circle ITEM 435

Solenoid Valves

Line of electrically operated two-way solenoid valves for air, gas, steam and liquid flow control is subject of catalog 200. Listed are dimensions, specifications, pressures and applications of stainless steel and bronze valves in sizes to 3 in. for pressures to 1500 psi. Atkomatic Valve Co.

—Circle ITEM 436

Cylinders

Mounting dimensions and specifications on eight standard 1 to 3-in. bore and seven 4 to 8-in. bore Spacemaker cushioned and noncushioned cylinders are given in illustrated bulletin SM-155-3. Air ratings are to 200 psi and oil ratings are to 750 psi. 6 pages. Tomkins-Johnson Co.

—Circle ITEM 437

High Pressure Lubricators

Described in service instruction sheet are type A lubricators—gear pumps driven through gears by machine on which they are used or by a small motor. Operation and maintenance are detailed. 2 pages. Bijur Lubricating Corp.

—Circle ITEM 438

Computer Components

Illustrations, details and outline specifications of mechanical and electrical components used in analog and digital computers are found in illustrated folder. 4 pages. Librascope, Inc.

—Circle ITEM 439

Hydraulic Pumps

Control centers for hydraulic systems are described in illustrated bulletin 102 "Powerpaks and Hand Pumps." Powerpaks are directional

FLEXIBLE TUBING FOR INDUSTRY

On air intakes, fuel lines, exhaust lines, Penflex Flexible Tubing has proved itself in plants across the nation. Rugged . . . tough . . . flexible Penflex Tubing is made to stand the most severe usage.

From ⅛" to 24" I.D. . . . bronze, galvanized or stainless steel Penflex makes all types and sizes of flexible metal tubing. Penflex "Flexineering"—the science of applying flexible tubing to fit the particular needs of your plant—assures the right tubing on each installation.

When you require metal tubing that is tight as a pipe, but flexible . . . safe at high temperatures . . . and free from metal fatigue specify Penflex. Write for your copy of "Flexineering" today.

Pennsylvania Flexible Metallic Tubing Company, Inc.,
7239 Powers Lane, Phila. 42, Pa. *Branch Sales Offices:*
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HEART OF INDUSTRY'S
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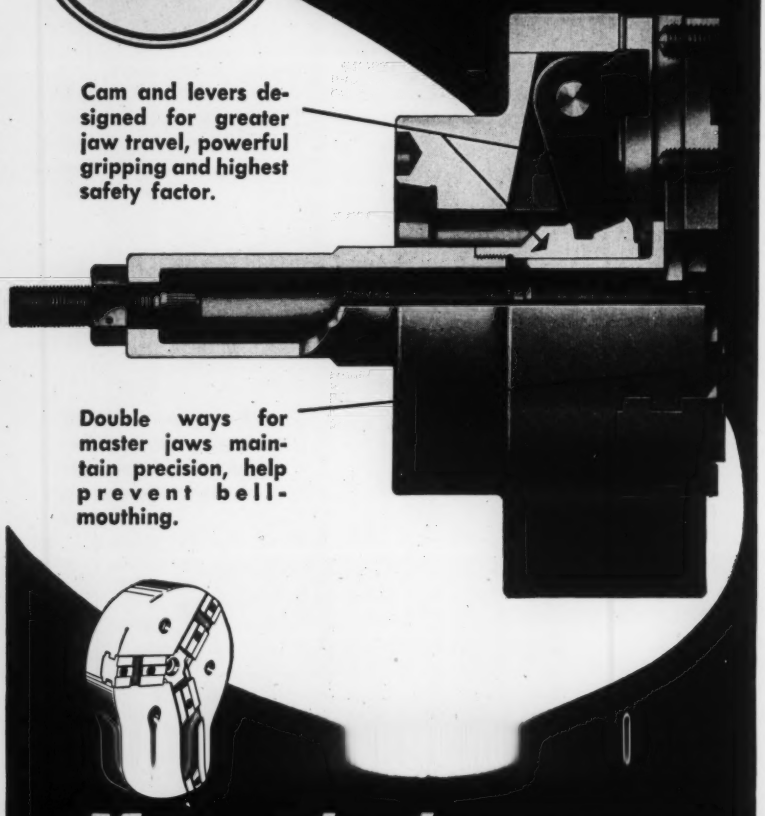
POWER CHUCKS



Cam and levers designed for greater jaw travel, powerful gripping and highest safety factor.

Double ways for master jaws maintain precision, help prevent bell-mouthing.

More gripping power

Famous S-P cam and lever design holds the work tighter, permits cost-cutting heavy feeds and multiple cuts. Cam and lever design also resists opening of jaws by centrifugal force or diminishing air pressure . . . an important safety factor.

Installed as original equipment by Bardons & Oliver, Cleveland Automatic, Cone Automatic, Ex-Cell-O, Monarch, Warner & Swasey . . . many others.

Representatives in principal cities. Prompt deliveries. Send for Catalog 105. The S-P Manufacturing Corp., 12415 Euclid Ave., Cleveland 6, Ohio.

S-P ROTATING AIR CYLINDERS

Piston packings "replace" themselves, cut downtime. Send for Catalog 105.

THE S-P MFG. CORP. — Cleveland
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PRECISION PRODUCTS SINCE 1916

AIR AND HYDRAULIC CYLINDERS • POWER CHUCKS • ROTATING AIR CYLINDERS
COLLET AND DRILL PRESS CHUCKS • AIR PISTONS VALVES AND ACCESSORIES

Helpful Literature

control valves with built-in components of a complete system for pressures to 1500 psi. 4 pages. Electrol Inc.

—Circle ITEM 440

Honeycomb Adhesives

Data on adhesives for honeycomb structures are content of technical bulletin. Test procedures and honeycomb sandwich materials and construction details are covered. 20 pages. Minnesota Mining & Mfg. Co., Adhesives & Coatings Div.

—Circle ITEM 441

Cylinders & Valves

Series QH 1000-psi and RH 2000-psi oil hydraulic cylinders and hydraulic directional control valves are described and illustrated in catalog No. 22 A. Technical data and complete specifications are presented 36 pages. Pathon Mfg. Co.

—Circle ITEM 442

Plastics

Catalog of various thermoplastic and phenolic sheets, rods, tubes and films also lists resins, cements and supplies. Included are comparison table of chemical, electrical and mechanical properties, colors, weight ranges and prices. 52 pages. Cadillac Plastic & Chemical Co.

—Circle ITEM 443

Silicone-Based Paints

Design and maintenance advantages of silicone-based finishes are evaluated in illustrated folder 7-903. Case histories illustrate usefulness of various types. Manufacturers using silicones in their paints are listed. 4 pages. Dow Corning Corp.

—Circle ITEM 444

Air Valves

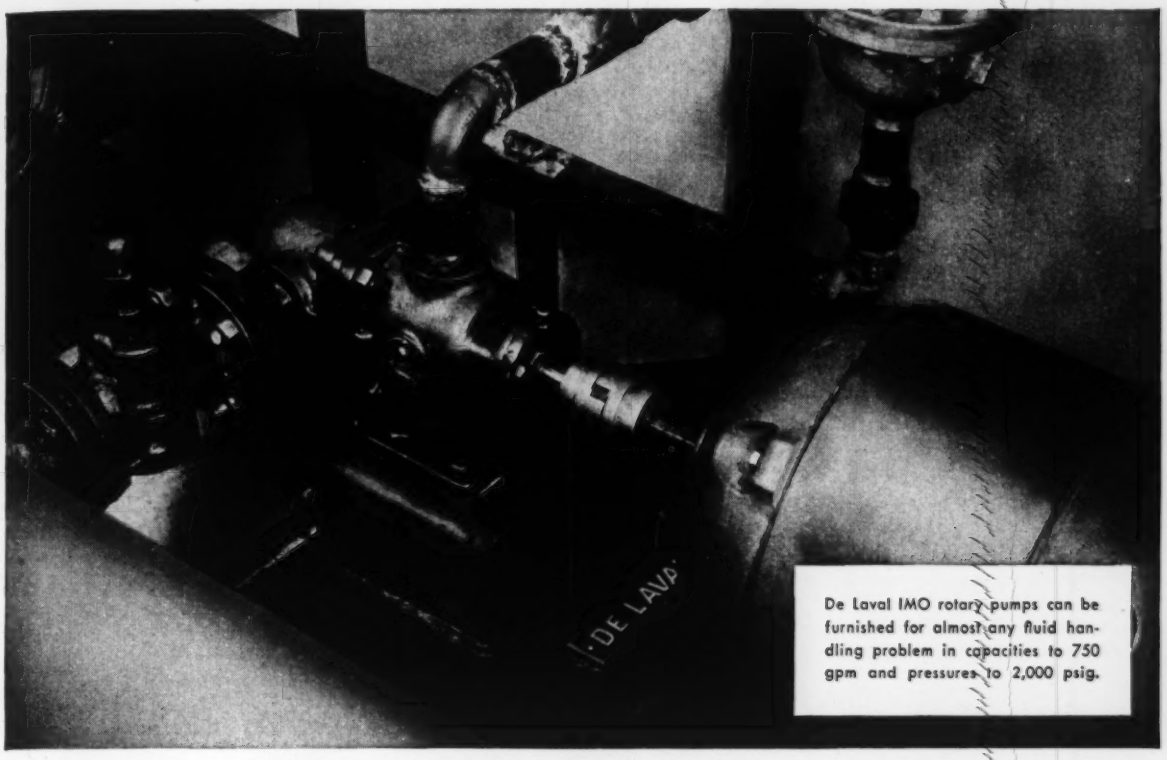
Line of air devices designed to eliminate air leaks is subject of illustrated circular 587. Included are air cocks and nozzles, and pop and safety, globe and angle, quick opening and air compressor check valves. 4 pages. Lunkenheimer Co.

—Circle ITEM 445

Investment Casting

Nine different applications of the investment casting process to products in as many industries are detailed in illustrated booklet. Advantages are outlined. 4 pages. Arwood Precision Casting Corp.

—Circle ITEM 446



De Laval IMO rotary pumps can be furnished for almost any fluid handling problem in capacities to 750 gpm and pressures to 2,000 psig.

What to Look for in a Rotary Screw Type Pump

By W. J. MONCON, *Assistant Chief Engineer*
De Laval Steam Turbine Company

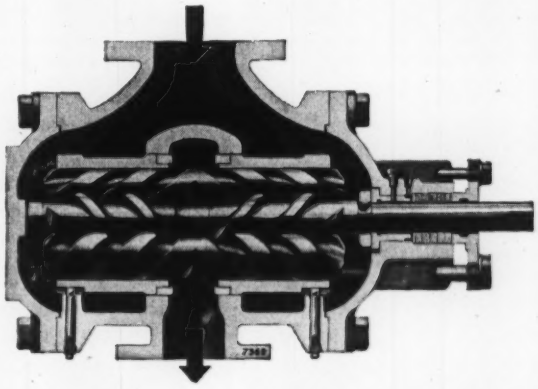
A sound knowledge of design, and how it affects performance, is the best insurance a buyer can have that he will get the pump he needs. This brief analysis of the IMO, a rotary three-screw pump manufactured by the De Laval Steam Turbine Company, will give you some of the necessary facts.

What qualities should you look for in a rotary type pump? It must, of course, meet specified capacities and pressures. But, it must also be efficient, operate quietly, stay on the job.

The axial flow of a screw type pump, and the resulting low inlet losses for any given pump speed, are important benefits that should be considered in making pump selections. The absence of timing gears and other mechanical features of construction also enable the De Laval IMO pump to operate at direct-connected motor and turbine speeds . . . to handle viscous liquids and high suction lifts.

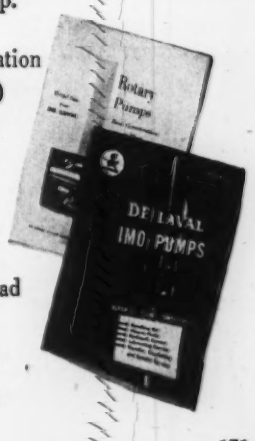
One of the most important features of the IMO pump is the hydraulic turning of the idler or sealing rotors. The central or power rotor is the pumping element; the liquid pumped turns the sealing rotors.

A screw type pump is well suited for applications where pulsation-free flow is desirable. The axial flow of the liquid without trapping and the unique thread form which keeps closures fluid-tight contribute to quiet operation of the IMO pump.



This is a cross-section of the De Laval IMO Series A322A, a positive displacement rotary screw type pump.

Catalog LS gives useful application and specification data on the IMO pump. An article titled, *Rotary Pumps, Basic Considerations in Their Application*, contains a description of rotary pumps in general. For these publications, write on your company letterhead to De Laval Steam Turbine Company, 858 Nottingham Way, Trenton 2, New Jersey. DL-301



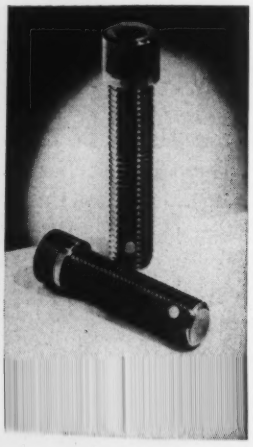
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Self-Locking Screws

have nylon insert to eliminate lock washers

Uniform locking force from top to bottom of the screw is provided by a nylon insert in this line of socket-head fasteners. Nylon pellet, inserted in a hole drilled in the threaded portion of the bolt, is compressed between mating threads when the bolt is screwed into a tapped hole or standard nut. Pressure between nylon and threads increases the friction between the metal thread surfaces and prevents loosening by vibration. The insert eliminates the need for



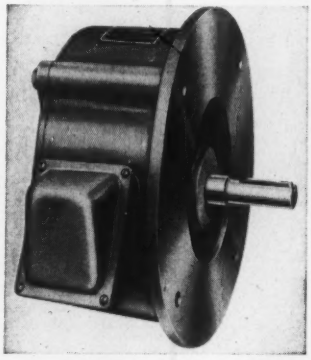
external locking devices, such as lock-washers, adhesives and wired heads. Screws are available in a full range of sizes from No. 6 upward. **Standard Pressed Steel Co.**, Stewart Ave., Jenkintown, Pa.

—Circle ITEM 451

Flat-Type Motor

requires minimum installation space

For use where installation space is limited, this flat-type motor meets NEMA design B specifications and is available in totally-enclosed fan-cooled or totally-enclosed nonven-



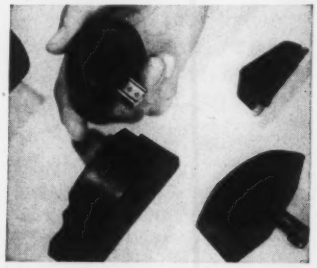
tilated designs. No precision air-gap adjustments or alignments are necessary since the motor is constructed like a conventional squirrel-cage unit. Operating at 208, 220/240 or 550 v, 2 or 3-phase ac (60 cps), it is available in ratings from 1/3 to 7½ hp, continuous or intermittent duty. **Diehl Mfg. Co.**, Finderne Plant, Somerville, N. J.

—Circle ITEM 452

Rubber Floats

will not fail due to puncture or vibration

Fabricated to customer specification, these hard unicellular rubber-sponge floats are suitable for use in water, oil, gasoline (including aviation fuels) and various other liquids. Lighter than cork, the sealed-cell sponge material resists



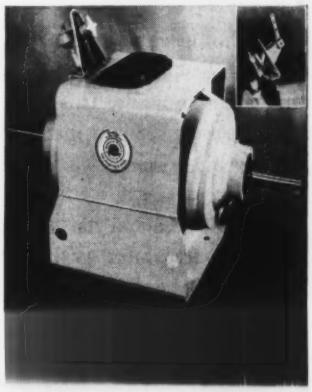
fungus growth, withstands high temperatures, needs no protective coating and will not become "waterlogged." It maintains stable weight and volume and will not fail due to vibration or puncture. Molded to shape with or without a metal mounting arm, the floats can be easily machined. **Parker Appliance Co.**, Rubber Products Div., 17325 Euclid Ave., Cleveland 12, O.

—Circle ITEM 453

Adjustable-Speed Drive

Can be manually or automatically controlled

This Gyrol adjustable-speed fluid drive can be used with conventional single-speed electric drive motors to provide manual or auto-



matic stepless speed control. Totally enclosed and self-contained, the unit consists of an input-shaft impeller and an output-shaft runner. Variation of casing oil level, by means of a manual or automatically operated scoop, controls the output speed with uniform accuracy and repeatability. Maintenance on the drive is negligible, usually requiring only a yearly oil change or chemical analysis. Torque, speed, transmission ratios and power output determine whether an external oil cooler is required. Drives are available in four sizes with ratings from 1 through 25 hp at operating speeds

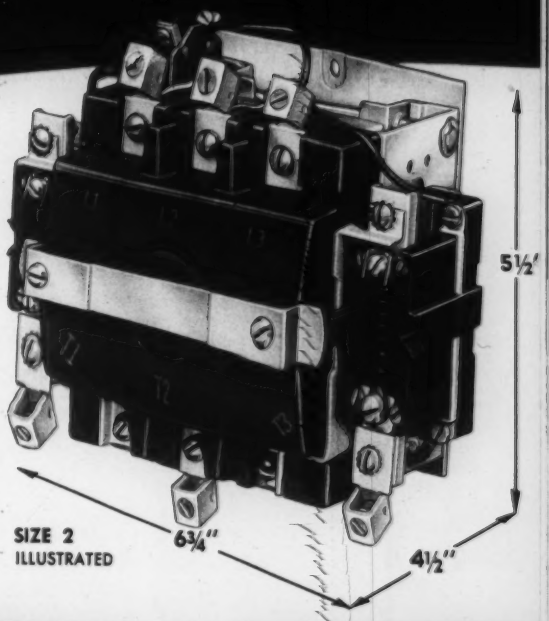
Facing Page—ITEM 599→

BY FAR THE *Finest* EVER BUILT

and HALF THE SIZE of Conventional Types

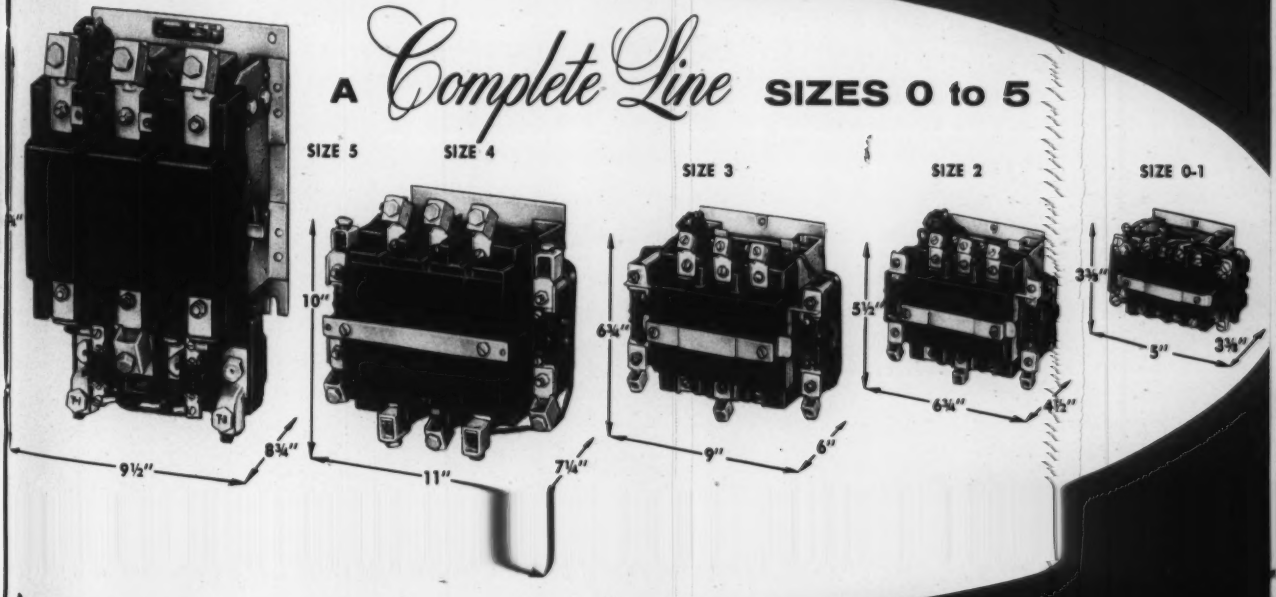
ARROW AH HART

MAGNETIC MOTOR CONTROLS



SIZE 2
ILLUSTRATED

A *Complete Line* SIZES 0 to 5



When SMALL Space is a BIG Design Problem! . . .

With these ALL NEW Features in Sizes 0 and 1 . . .

-
-
-
-

ARROW AH HART

THE ARROW-HART & HEGEMAN ELECTRIC CO., Hartford 6, Connecticut

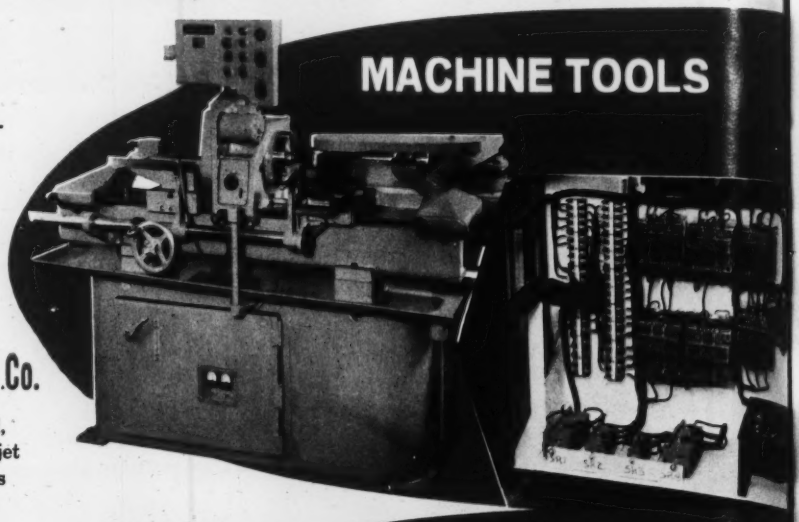
The Leaders look to ARROW AH HART *Advance Design*

MOTOR CONTROLS

. . . FOR SPACE-SAVING COMPACTNESS

. . . FOR PERFORMANCE-BUILDING DEPENDABILITY

MACHINE TOOLS



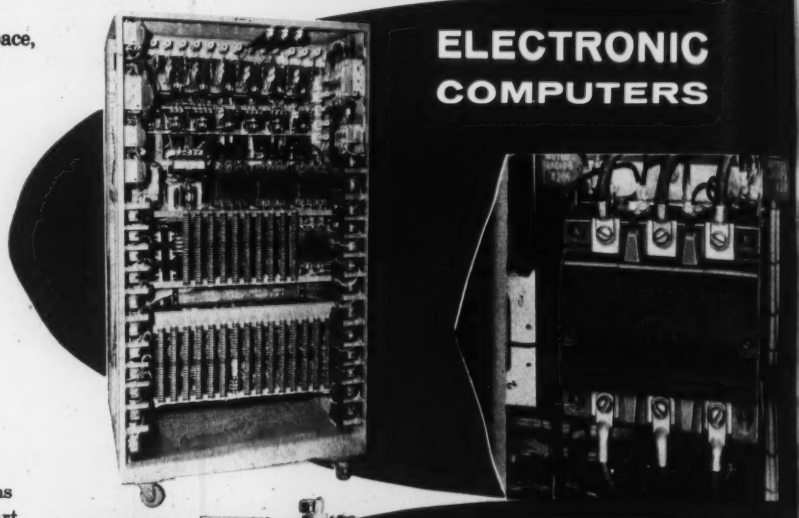
MODEL 102 AIRFOIL MILLING MACHINE

MANUFACTURED BY

The New England Machine & Tool Co.

This ingenious machine mills the original, 3-dimensional masters from which turbo jet blades are manufactured . . . does in hours a job once requiring weeks of hand work. Complexity of the operating and control mechanisms placed a high premium on space, but the 5 smaller, lighter A-H Magnetic Controls were easily mounted on an unusually compact door-back panel that swings out for instant accessibility.

ELECTRONIC COMPUTERS



TYPE 704 ELECTRONIC DATA PROCESSING MACHINE

MANUFACTURED BY

International Business Machines CORPORATION

These electronic machines are designed primarily for the use of engineers and research scientists. They are capable of performing more than 4000 multiplications or divisions per second. The 10 Arrow-Hart Contactors included in the very complicated power distribution unit were a natural choice to save valuable space. Other A-H Controls are also utilized in other parts of the machine.

HEATING EQUIPMENT

HEV-E-OIL BURNER

MANUFACTURED BY

Cleaver-Brooks Company

Simple, compact and efficient, this modern unit uses low cost, high heat heavy oils to provide economical heat for commercial and industrial buildings. Arrow-Hart Control – an "RA" Starter and a Miniature Relay – occupies little space in the small panel, leaves ample space for easy wiring.

ARROW AH HART

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 Hawthorn Street, Hartford 6, Connecticut
MOTOR CONTROL DIVISION

Please send my copy of the A-H Motor Control Application folder. MD

name _____

position _____

company _____

co. address _____

city _____ zone _____ state _____

ARROW-HART

MOTOR CONTROL DIVISION
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 HAWTHORN STREET, HARTFORD 6, CONNECTICUT

Offices, Sales Engineers and Warehouses in Principal Cities

Quality MOTOR CONTROLS • WIRING DEVICES
ENCLOSED SWITCHES • APPLIANCE SWITCHES

MAIL COUPON TODAY FOR COMPLETE INFORMATION

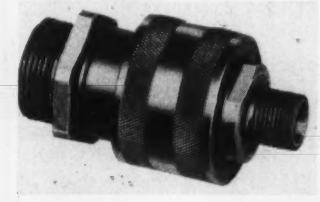
of 1200, 1800 and 3600 rpm. Input and output connections can be direct, belt or chain. **American Blower Corp.**, Detroit 32, Mich.

—Circle ITEM 454

Quick-Disconnect Coupling

seals positively against 35-*g* accelerations

There is no intermediate or partially-locked position for this self-sealing hydraulic coupling, which



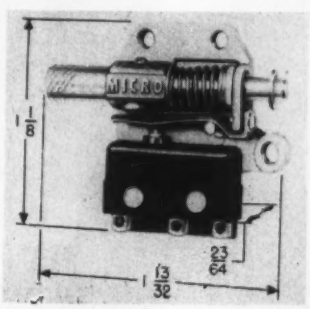
locks with a simple push. The lock is positive and may be checked by visual inspection, or by physical feel of the operating sleeve. A direct pull on the coupling disconnects and positively seals each half. Accidental uncoupling cannot be caused by repeated 35-*g* accelerations. Withstanding 60 psi, the coupling is available with standard fittings and a bulkhead flange. **Weatherhead Co.**, Aviation Div., Antwerp, O.

—Circle ITEM 455

Door Interlock Switch

is rated 5 amp, 125 or 250 v ac

This subminiature switch, designated 7AC1-T, for use on radio, radar, X-ray and other high-frequency equipment cabinets, is designed to cut off power automatically when a service door is opened. Manual rod actuator allows circuits to be checked with



(Continued on Page 178)

IMMEDIATE DELIVERY

ANY SIZE • ANY MOUNTING • ANY STROKE

from CARTER

why wait for delivery on . . .

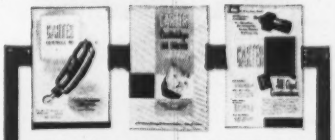
CYLINDERS

AIR OR HYDRAULIC

Don't let cylinder delays hold up your production. Carter will give you IMMEDIATE DELIVERY on standard cylinders — *any bore size, any mounting, any stroke!* This is due to our recent 100% expansion in plant capacity, 3 shift operations, and the exclusive CARTER design which permits off-shelf assembly from standard parts.

This is the way we can and do serve our customers, regularly, day in — day out. We will serve you the same way. Call on us today for IMMEDIATE DELIVERY.

BUILT-IN VALVE TYPES | AIR VALVES | CLAMP CYLINDERS



COMPLETE FILE OF BULLETINS

All the details you need. Prices, specifications, spare parts information. Send for your complete file today.

AIR CYLINDERS | 750 LB. HYDRAULIC | 1500 LB. HYDRAULIC

CARTER Cylinders feature:

STRENGTH - DURABILITY — Precision honed heavy wall tubing . . . 10 to 1 safety factor . . . heavy duty chrome plated rod as standard. Long life, leakproof performance.

SIMPLICITY OF DESIGN — Integral cast steel head and mount united with cylinder wall by means of key type lock ring. 360° orientation of pipe ports. Leakproof construction.

EASY MAINTENANCE — Easily disassembled. Replacement of parts is simple, quick. No skilled help needed. Cartridge Rod Bearing allows on-the-job replacement without disassembly of cylinder.

SPACE SAVING ADVANTAGES — No bolts, no tie rods . . . Carter's compact design of both cylinder and mount saves 40% in space.

CARTER

AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS

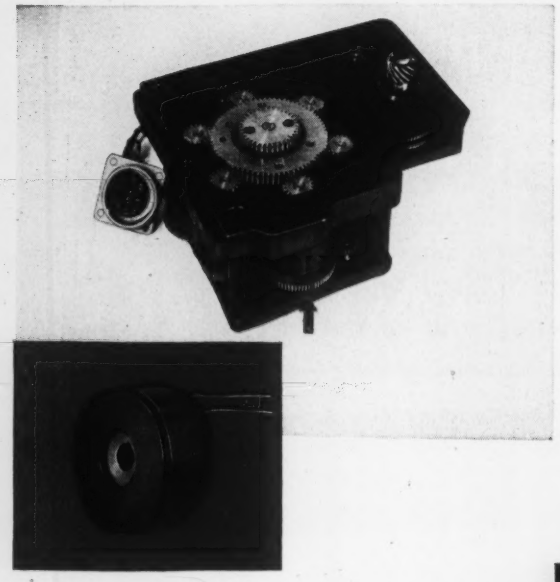
ROTARY ACTUATORS • SPECIAL CONTROLS

—ITEM 600—

get MATCHED-TO-THE-MACHINE Power Transmission Control with Stearns Magnetic Clutches and Brakes

Stearns Magnetic, Inc. builds magnetic disc brakes, clutches and clutch-brakes to match your machine and transmission control problems exactly — whether you design small-precision instruments like cameras and business machines, or large equipment like ball mills or milling machines. Clutches and brakes can be custom-built to specification or you can choose from a wide range of standard models.

Here are a few examples of how Stearns equipment solved widely different transmission control problems.

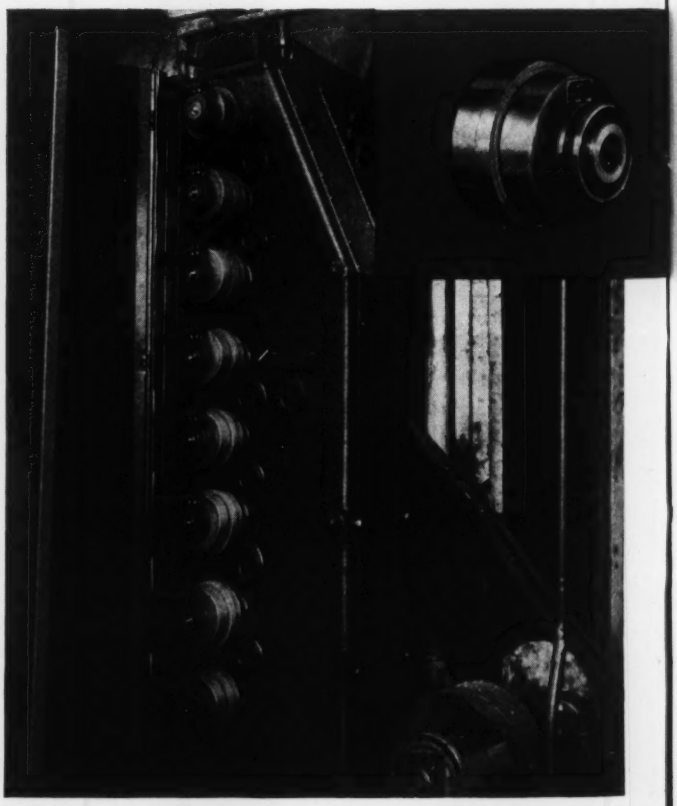


Stearns miniature camera clutch eliminates manual gear shifting, greatly improves camera fade control

Acme Camera Corp., Burbank, California, employed a manual gearshift device to obtain variations for fade-in, fade-out action of its motion picture camera. This design not only necessitated reaching around the entire camera to shift gears, but also caused damage due to shifting gears while running.

Stearns Magnetic transmission specialists, working with Acme engineers, designed a miniature magnetic clutch which permits remote control of the fade-out mechanism. Clutch is designed to provide high torque, yet is only 1 inch long, 1⅜ inches in diameter. Each camera uses six Stearns clutches to provide six separate fade speeds.

Miniature clutches like these are opening new fields to automatic control. Stearns engineers will be happy to discuss your problems with you.

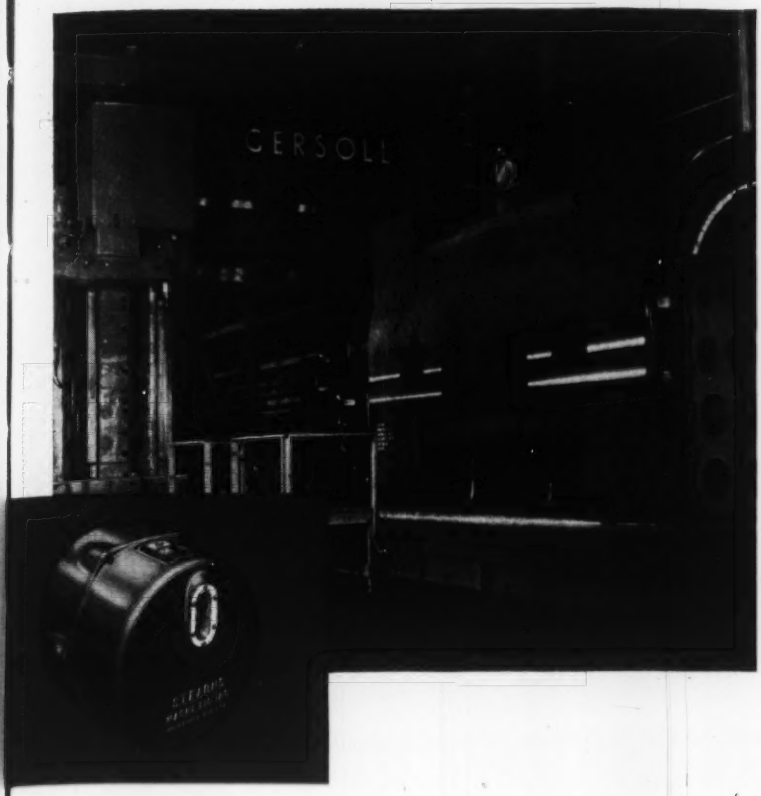


Coe fiberboard dryers keep 'em rolling—automatically—with Stearns heavy-duty magnetic clutches

On the big jobs too, Stearns Magnetic Disc Clutches provide the answer to automatic control problems. Coe Manufacturing Co., Painsville, Ohio, builds completely automatic veneer and fiberboard dryers using from eight to twelve Stearns Style "E" clutches per machine.

Illustrated here is the feed section of an 8-deck Coe Dryer. Fiberboards are automatically fed successively to each deck by means of a tipple driven through a Stearns clutch. When the tipple directs a fiberboard to the bottom deck, the bottom clutch automatically engages and the board is pulled into the dryer. Then, when tipple tilts up to the next deck, bottom clutch disengages, and clutch immediately above engages and a board goes into second deck, etc., until cycle is completed. Entire operation from feed through dry to discharge is continuous, automatic.

Machine handles up to 50 ft of board per minute. Each Stearns clutch in the dryer bank is 8 inches in diameter, which provides an extra margin of long life and dependability. Clutch requires very little maintenance, provides cool operation and is simple to install — no toggles, yokes or shifters.



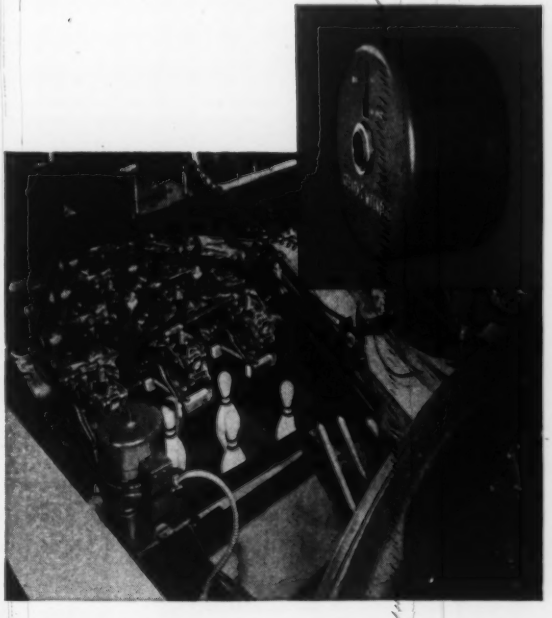
Stearns brakes lock cutterheads in position on world's largest milling machine

Weighing over a million pounds, this milling machine, built by Ingersoll Milling Machine Co., Rockford, Illinois, mills parts up to 18 ft wide, 16½ ft high and over 50 ft in length. In milling such large, costly pieces exact positioning of cutterheads is extremely important. Five 1000 series, heavy-duty Stearns brakes are used for these precision-control functions—four brakes individually lock each of the four cutterheads securely and exactly in place, while the fifth brake locks the cross-rail in position. Positive, powerful gripping action is essential as the head locked by each brake must be held securely while a 100-hp motor drives the cutter.

One operator controls the various elements of the machine. With push buttons, switches and dials, he can start, stop, speed up or lock individual units in place.

Stearns brakes have chalked up a long record of dependability on many Ingersoll machines, including horizontal spindle, open-side milling and boring machines.

Stearns magnetic brakes provide accurate cycle control for AMF automatic bowling pinspotters



Fast, sure stopping of electric motors is an absolute must for accurate cycle control of American Machine and Foundry's amazing Automatic Pinspotter. Two Stearns Magnetic disc brakes handle this important job — one brake controls the motor which actuates the pinspotting table, the other controls the sweep bar motor. Five separate stops are required in each complete operating cycle. With the positive stop action provided by the Stearns brakes, there is no chance of motor overrun which would upset the perfect coordination and accuracy of the pinspotter's various operating functions.

The Stearns Style HT 50 brakes used on this machine are designed for through shaft applications. Motor is ⅓ hp and brake provides 3 ft lb maximum torque. Brake is spring-set and solenoid-released—it automatically sets in event of power failure.

Simple, rugged construction and trouble-free operation of this brake makes it ideal for any precision operation requiring frequent stop-starts.

Stearns brakes and clutches help you improve machine design and performance

Get the complete story on Stearns magnetic brakes, clutches and clutch-brake combinations. Check the many features that make these Stearns units the choice of leading design engineers for solving hundreds of widely different power transmission and control problems — on small and large machines alike. Send the convenient coupon or write us in detail describing your problem.

1154

Please send:

- ☐ *Brake portfolio 604-F-4*
- ☐ *Clutch Bulletin 226 D*
- ☐ *Brake Portfolio and Clutch Bulletin*

Name..... Title.....

Company.....

Street Address.....

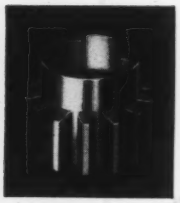
City..... State.....

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

STEARNS MAGNETS

Stearns Magnetic, Inc., 692 S. 28th Street, Milwaukee 46, Wis.

—ITEM 601—

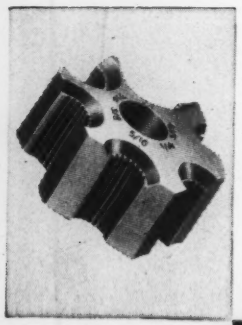


GIVING YOU

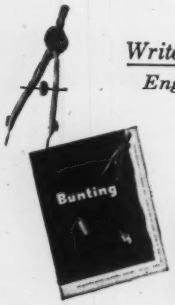
...the best and most modern!

Bunting today covers a new area in the engineering and manufacture of bearings and machine parts. To the traditional line of Bunting Cast Bronze Bearings and parts is added up-to-date, soundly established facilities for engineering and manufacturing bearings and parts made of Sintered Powdered Metals.

In an entirely new plant with the very latest equipment, Bunting now attains the position in the Sintered Powdered Metals field which it has long held in the field of Cast Bronze Bearings.



A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.



Write to our Product Engineering Department in Toledo, or consult our nearest Sales Engineer.

Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

—ITEM 602—

For More Information Circle Item Number on Yellow Card—page 19

New Parts

(Continued from Page 175)

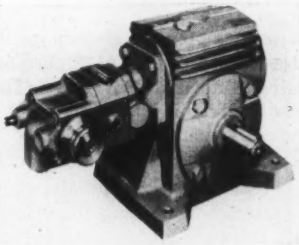
power on. Rod automatically returns to normal position when the door is closed. Basic switching element has fine-silver contacts and a precision snap-action spring. Contact arrangement is single-pole, double-throw. Total travel in either direction of the actuator plunger is about 5/32-in. Size of the assembly is 1 13/32 x 23/64 x 1⅛ in. Electrical rating is 5 amp, 125 or 250 v ac; 3 amp, 30 v dc (inductive or resistive) at sea level; maximum inrush, 15 amp. **Minneapolis-Honeywell Regulator Co.,** Micro Switch Div., Freeport, Ill.

—Circle ITEM 456

Speed Reducer

combines speed reduction with torque multiplication

Applicable for relatively low-power, variable-speed service, this fluid-motor speed reducer provides low output speeds with torque multiplication. Overloading at maximum torque input to the speed reducer is prevented by a built-in relief valve. Furnished with or without a speed-control valve, the reducer can be provided in a range of ratios, and with speed-control valves handling fluid rates from 2 to 6 gpm, maximum. Gear widths available are ½, ¾ or 1 in. **John S. Barnes Corp.,** Rockford, Ill.



—Circle ITEM 457

Vertical Motors

are low-maintenance units for water-pumping service

Tri-Clad 55 line of vertical, hollow-shaft motors has been designed to meet the special requirements of water-pumping service. Ratings run from 7½ through 30 hp; thrust capacity can be increased by removing the spacer ring in the

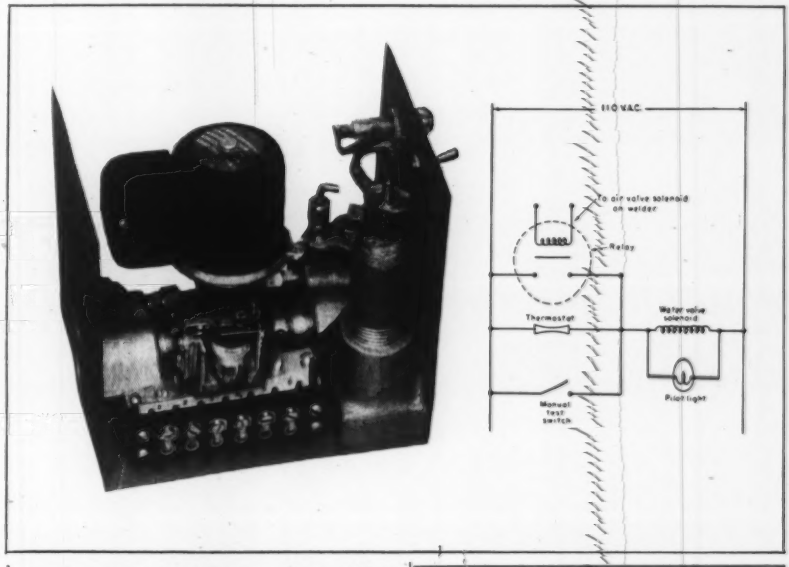
How to Control Cooling Water

No. 5 of a series — *Showing the Broad Application Range of Fenwal Controls*

The Water Mizer is used for resistance welders, induction-heating equipment and hydraulic systems. The unit turns on the cooling water at the initiation of a cycle by means of a relay tied into the operating cycle.

The problem was to stop the water flow to the electrode after the machine is idle for a time long enough to cool the electrodes. Here's how a Fenwal THERMOSWITCH unit solved it —

When the welder is started, the Water Mizer, through a relay control system connected to the air solenoid valve coil or clutch on the welder, releases a full flow of water. The relay control keeps the water valve open until the cooling water becomes warmer than the Fenwal THERMOSWITCH setting, at which time the THERMOSWITCH takes over and controls the flow according to operating requirements.



FENWAL THERMOSWITCH unit provides control of cooling water in the Water Mizer, a coolant control for welding and brazing made by Van Vooren Products, East Moline, Illinois. Compact Fenwal units are easily adjustable, highly resistant to shock and vibration and are totally enclosed against dust and dirt.

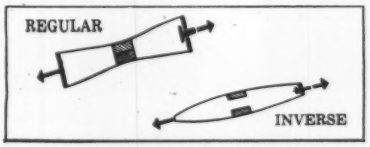
How Fenwal Thermoswitch Units Operate

In THERMOSWITCH thermostats the activating *control* element is the metal shell which encases the contact elements. Changes in temperature cause the shell to expand or contract instantaneously. This exerts either tension or compression on the struts, causing the contacts to make or break a circuit. Control in the Fenwal THERMOSWITCH units is calibrated at a given shell temperature by turning the adjusting screw until contacts operate.

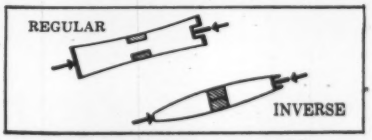
Fenwal THERMOSWITCH controls are constructed as either tension or compression operated with regular or inverse contact arrangements.

Tension operated units may be subjected to momentary temperature exposure of 100°F above their set point. They also may be subjected to any temperature below their set point without danger. Tension operated Fenwal THERMOSWITCH units may be set below 0°F but compression operated units are recommended if rapid temperature changes in excess of 100°F or extreme temperature overshoots are to be encountered.

Fenwal compression operated units may be exposed to a temperature of −100°F indefinitely, and to temperatures 400°F above their set temperatures for short periods of time.



TENSION OPERATED



COMPRESSION OPERATED

The Fenwal THERMOSWITCH Control is constructed with two silver contacts mounted on, but electrically insulated from, curved nickel-iron struts of low expansion coefficient. This element assembly is then mounted under tension or compression in a seamless drawn brass or stainless steel tube. The amount of tension or compression is variable, depending on the position of the adjusting sleeve and the temperature of the shell.

Proved Applications

Fenwal Sales Representatives and Engineers have saved time, trouble and money in all types of plants and laboratories by solving thousands of temperature control and detection problems. Fenwal THERMOSWITCH units are controlling processes that involve liquids, gases and solids.

Put Fenwal's vast reservoir of technical know-how to work for you. Chances are your problem has already been met and mastered by Fenwal engineers.

Write for new Catalog No. 500 for details and complete product listings on Fenwal THERMOSWITCH Thermal Controls, including units discussed above, Midget and Miniature versions of these, Snap-Action Controls, and Indicating Controllers.

FENWAL INCORPORATED
193 Pleasant Street
Ashland, Mass.

Please send me your Catalog No. 500. Our specific problem is: .....

.....

.....

Name ..... *Title* .....

Address .....

City ..... *Zone* ..... *State* .....

Fenwal CONTROLS TEMPERATURE . . . PRECISELY

—ITEM 603—

SOCKET SET SCREWS

SOCKET CAP SCREWS

FLAT HEAD SOCKET SCREWS

SOCKET SHOULDER SCREWS

"LED-LOK" CAP SCREWS

"SAF-LOK" CAP SCREWS

SOCKET PIPE PLUGS

SOCKET KEY KITS

QUALITY AT YOUR FINGERTIPS!

When you take one of these Blue Devil Socket Screws in your hand, you'll know what we mean by quality. You'll quickly see they're strong, well designed and precision-manufactured . . . by exclusive specialists in socket screws. Next time, insist on Blue Devil Socket Screws . . . available through leading industrial distributors.

Blue Devil SOCKET SCREW PRODUCTS

Sold only through Authorized Industrial Distributors

ACTUAL CROSS-SECTION DIAGRAM shows how cold forming of Blue Devil Socket head insures unimpaired fiber continuity.

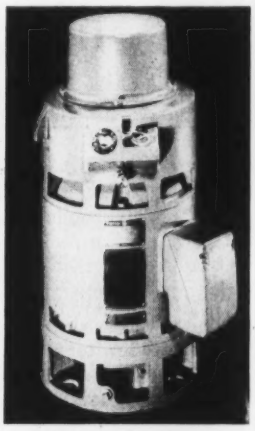
SAFETY SOCKET SCREW COMPANY

6510 North Avondale Avenue, Chicago 31, Illinois

Socket Screws Exclusively!

—ITEM 604—

New Parts



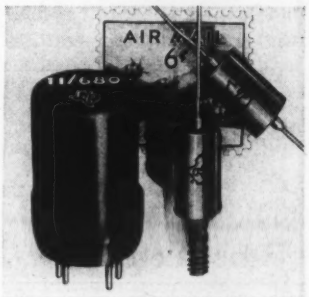
housing and inserting additional thrust bearings. For protection against driving rain, dust and other outdoor hazards, cooling air intake and discharge openings are fully baffled. Stator windings are Formex insulated and slot insulation is high-dielectric polyester film. Substantial reduction in heat generation results from use of pressure-cast aluminum rotor windings. **General Electric Co.**, 1 River Rd., Schenectady 5, N. Y.

—Circle ITEM 458

Silicon Rectifiers

with single-junction, 1500-v elements

For application in miniature high-voltage power supplies, these new silicon rectifiers incorporate a single grown junction element with a 1500-v breakdown voltage. Operation is stable at temperatures to 150 C, and forward-current ratings reach 100 ma. Avail-

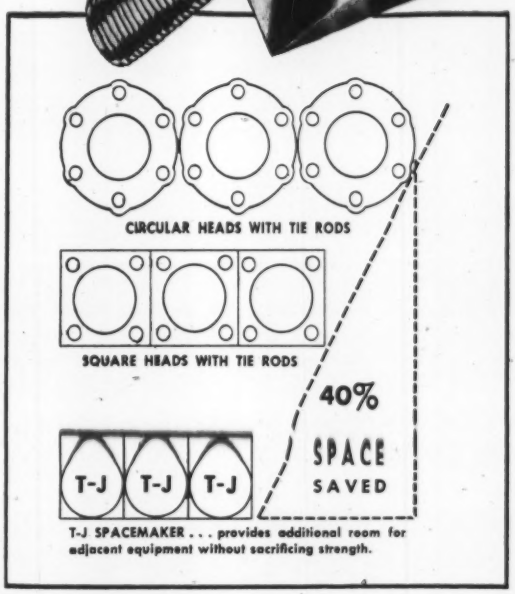


able in two types of axial and stud half-wave models and a full-wave plug-in model, these hermetically sealed units eliminate the need for filament power. The axial models, 1N543 and 1N543A, allow point-to-point wiring; types 1N544 and 1N544A are stud-mounted for maximum heat dissipation. Plug-

Saves 40% Space!

STRONGER, TOO

Than Outmoded Tie Rod Cylinders!



T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

Only T-J

Spacemaker CYLINDERS

Offer All The Extras As Standard!

- NEW *exclusive* Ingenious Cushion Designs . . . Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Oil Cushion
- Compact design eliminates tie rods, saves up to 40% space
- Proven Performance . . . with Extra High Safety Factor
- Hard Chrome Plated Bodies and Piston Rods (Standard, at no extra cost).
- Oil pressure to 750—AIR to 200 P.S.I.

You'll find many answers to *automation* in your plant with T-J Spacemaker Cylinders! Designed with years-ahead features for top performance and dependability. Wide range of styles, capacities . . . for all kinds of push-pull-lift operations . . . reduces man-hours and costs! Write The Tomkins-Johnson Co., Jackson, Michigan.

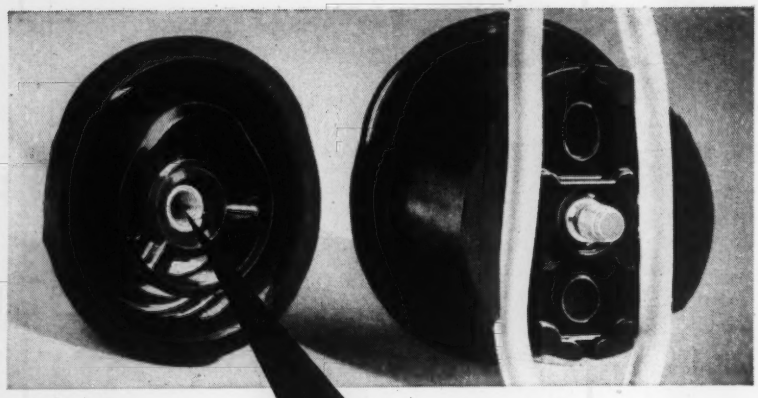
NEW LITERATURE . . . send today for new Bulletin with complete details of Spacemaker line.

MEMBER OF THE NATIONAL FLUID POWER ASSOCIATION

TJ TOMKINS-JOHNSON

RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

—ITEM 605—



PIP* **push inserts make perfect threads**

WITHOUT TAPPED HOLES OR SOLID BUSHINGS

Threads without tapping at less than 1¢ per hole installed. Just push-in-place a PIP Push Insert and you have perfect female threads in cast, molded or drilled blind or through holes. Spring-like PIP Inserts lock securely in place in plastic, aluminum, zinc and all other molding and die-casting materials.

The illustration shows a typical application. The PIP Insert in the cap of this common electrical socket provides threads strong enough to impale the two covered wires on contact prongs. The insert was pushed into a plain cored hole after molding, avoiding long cycle time required by molded-in solid bushings.

PIP Push Inserts are perfect for production line application. Either a drill press, kick press, arbor press or air piston—and a few dollars in tooling—are all you need to install perfect threads in 1,200 holes per hour.

Write today for samples and full information.

*Product of Heli-Coil Corp. —Pat. Pending

HELI-COIL CORPORATION
126 SHELTER ROCK LANE, DANBURY, CONN.

- ☐ Send Standard PIP Push Insert Application Chart and other information on this new technique.
- ☐ Send design data on *Heli-Coil* Screw Thread Inserts.
- ☐ Send design data on *Heli-Coil* Screw Lock Inserts.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____ 3054

Heli-Coil Corporation: Manufacturer of *Heli-Coil* Screw Thread Inserts, *Heli-Coil* Screw Lock Inserts and *Heli-Coil* PIP Push Inserts.

IN CANADA: W. R. WATKINS CO. LTD., 41 Kipling Ave. S., Toronto 18, Ont.

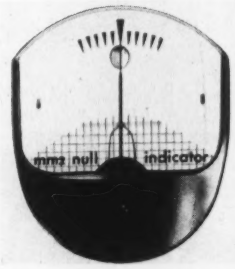
—ITEM 606—

in model, TI/680, can be used in many applications to replace the JAN 6X4 rectifier tube. **Texas Instruments Inc.,** Semiconductor Products Div., 6000 Lemmon Ave., Dallas 9, Tex.

—Circle ITEM 459

Null Indicator

does not overload with large signal inputs



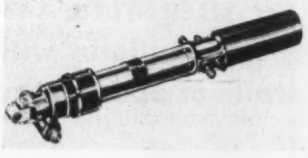
High null-point sensitivity, with square law attenuation on each side of the null point, permits accurate detection of large bridge unbalance signals without physical or electrical overload in this 2½ in. null indicator. High readability from all angles results from use of a long dial arc, large numerals and well-illuminated scale. The instrument is available in three different sensitivities (½, 1 and 2 microamp per mm at null); full-scale current ratings are 100, 200 and 500 microamp. **Marion Electrical Instrument Co.,** Grenier Field, Manchester, N. H.

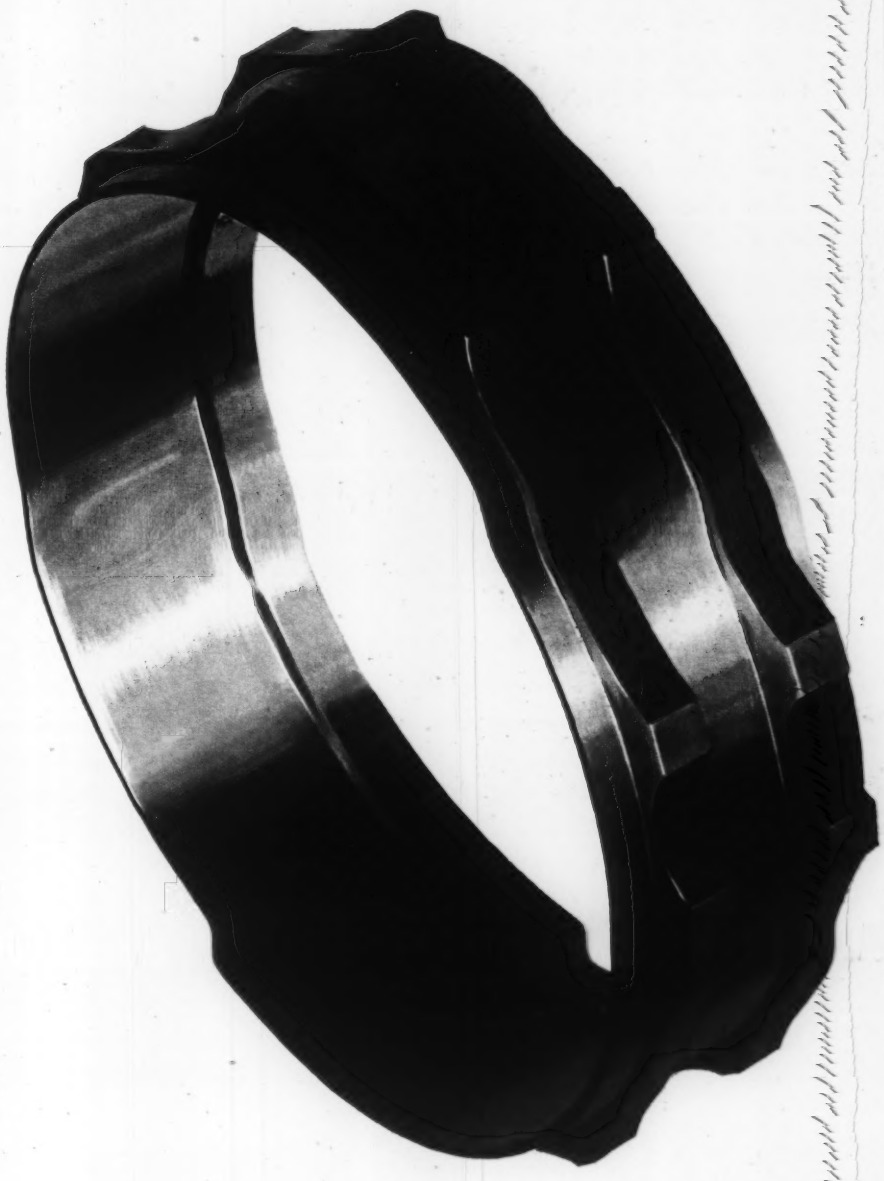
—Circle ITEM 460

Hydraulic Actuator

circulates fluid for high temperature performance

Constantly circulating fluid and precision metal-to-metal contact between moving parts are design features that permit operation of this synchronous hydraulic actuator at temperatures in excess of 800 F. Suited for industrial or aircraft application, it can be positioned to close tolerances and can be accurately synchronized with





IT'S CRITICAL

IT'S COMPLEX . . . . . IT'S FORGED

This critical jet engine "case ring" with its odd protrusions, thin section and large diameter, would have been a designer's dilemma a short time ago.

Today, Cameron's advanced forging technique, developed on some of the world's largest and most unusual presses for ferrous forgings, has opened new vistas of design, high production and economy.

WRITE

Cameron

IRON WORKS, Inc.

SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas

Required: Strength . . . Analysis . . . Quality . . . Economy

Specified: **ACIPCO** Centrifugally Spun **STEEL TUBES**

In applications such as the many hydraulic cylinders for the stretch former for aluminum sheet shown here, as well as in hundreds of others — reformer tubes for chemicals, oil well diamond drill bits, heavy duty rolls — Acipco centrifugally spun steel tubes meet the rigid requirements and specifications of design engineers.

Strength properties and exact metal analyses, as well as economy of initial and operating costs, are readily "engineered" into hundreds of tubular product applications through the versatile size and analysis range of Acipco centrifugally spun steel tubes.

Acipco's integrated facilities for casting, heat treating, machining, fabricating and testing — all located "under one roof" — provide prompt service in furnishing "custom-spun" tubes for your specific purpose . . . whether you need two, or two thousand.

Why not find out how, and why, Acipco steel tubes can serve your needs best? It costs nothing to arrange a consultation with Acipco's experienced engineers and metallurgists.

SIZE RANGE: Lengths up to 16'—longer lengths by welding tubes together. OD's from 2.25" to 50"; wall thicknesses from .25" to 4".

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels; plain carbon grades and special non-standard analyses.

FURNISHED: As cast, rough machined, or finish machined, including honing.

ACIPCO

AMERICAN CAST IRON PIPE CO.

ACIPCO

Special Products Division

BIRMINGHAM 2, ALABAMA

DISTRIBUTORS

Austin-Hastings Co., Inc.
226 Binney St.
Cambridge 42, Mass.

Peter A. Frasse and Co., Inc.
17 Grand St.
New York 13, N. Y.

Lyman Tube & Bearings, Ltd.
920 Ste. Sophie Lane
Montreal 3, Canada

J. M. Tull Metal & Supply Co.
285 Marietta St., N. W.
Atlanta, Ga.

C. A. Roberts Company
2401 Twenty-fifth Avenue
Franklin Park, Ill.

Strong, Carlisle & Hammond Co.
1392 W. Third St.
Cleveland 13, Ohio

Ducommun Metals & Supply Co.
4890 So. Alameda St.
Los Angeles 54, Calif.

—ITEM 608—

For More Information Circle Item Number on Yellow Card—page 19

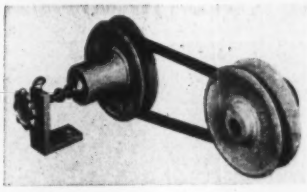
similar units in multiple-actuator installations. **National Water Lift Co.**, Div. of Cleveland Pneumatic Tool Co., 2220 Palmer Ave., Kalamazoo, Mich.

—Circle ITEM 461

Variable-Speed Drive

holds belt tension, shaft spacing constant

Available with ratings from 1/3 through 1 hp, this variable-speed drive employs two variable-pitch



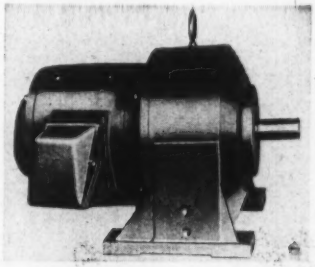
pulleys to give speed variations up to 7½ to 1. Pulley diameters supplied range from 3⅝ to 5¾ in., and stock bore diameters run from ½ to ⅞-in. Drive maintains constant belt tension and shaft-center spacing, needs no adjustable motor base. Driving speeds can be adjusted without stopping the motor. Pulley disks are machined cast iron, and bearings are oil impregnated. Through-bore permits mounting pulleys on either side. **Gerbing Mfg. Corp.**, 11800 Milwaukee Ave., Northbrook, Ill.

—Circle ITEM 462

Gearmotors

in wide selection of mounts, enclosures and speed ratios

New line of ac and dc gearmotors, with wide choice of mountings, enclosures and speed ratios, is available with ratings from 1 through 60 hp. Two-way seals, which effectively seal oil in and dirt out,



(*Continued on Page* 188)

INSTALL IT

FORGET IT!

. . . when it's a

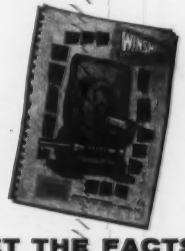
WINSMITH Speed Reducer

Get acquainted with the Winsmith line of speed reducers that are installed and forgotten because they never call attention to themselves as trouble-makers.

Next time you want to cut your r.p.m's. down to size accurately, under the most rugged operating conditions, specify Winsmith . . . the line of speed reducers that can be described in just one word — *dependable!* You'll find that their performance adds to the reputation of your equipment.

And, as a source of supply, Winsmith offers the most complete line of reducers within the range of 1/100 h.p. to 85 h.p. in ratios of 1.1:1 to 50,000:1. For complete details write for Catalog 155, described below.

WINSMITH
SPEED REDUCERS



GET THE FACTS!

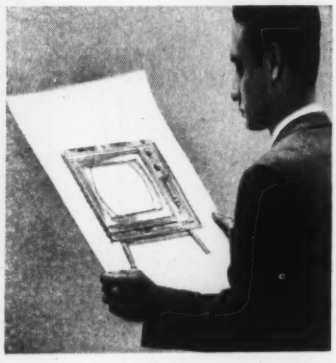
Catalog 155 describes the *new* "C" Series plus other units in the Winsmith line. Contains complete selection information for each model described.

WINSMITH, INC. 16 Elton Street, Springville, (Erie County), N. Y.

MONSANTO

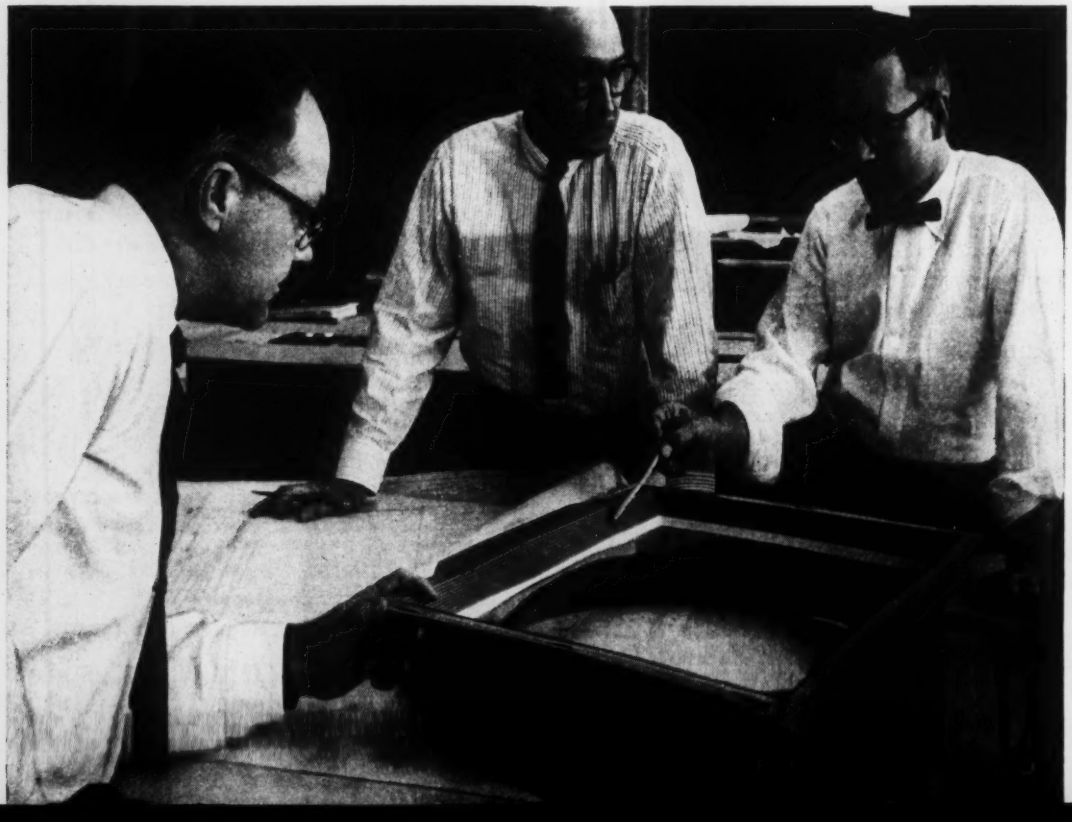
Competition for tomorrow's markets imposes a heavy responsibility on the men who design for industry. In their constant search for ways to improve products within definite cost boundaries, many of them are working closely with plastics engineers in the custom molding industry. These pages report on how the unique properties of plastics helped RCA designers create an important component for a color television set. It is more than likely that custom molders, who are devoting their lives to craftsmanship in plastics, can contribute to solving some of your problems.

How RCA designers engineered a color television mask in Lustrex styrene plastic



DESIGN OBJECTIVES. Model sketches for the new RCA Victor* color television set called for a mask opening which would frame the kinescope in established size and permit a maximum viewing angle. A leakage path of six inches was required between high voltage bearing metal surfaces and adjacent points on the instrument subject to spectator contact. The mask had to be capable of supporting the front end of the kine in the cabinet. It had to combine utility with attractive appearance, in a color that would not detract from the color kine picture.

MATERIAL SPECIFICATIONS. After studying various materials RCA designers and engineers decided that a rigid mask molded of styrene plastic would best meet objectives. While a thin covering of insulation would have met specifications electronically, it did not offer the mechanical strength to support the kinescope properly. RCA experience with high-impact styrene masks for monochrome receivers had demonstrated their ability to support and locate the kine in position. At the same time they protected users from direct contact with it. By custom molding the mask in one piece, the part could be supplied ready for assembly and painting.



PRODUCTION ENGINEERING. RCA commissioned Amos Molded Plastics Company, Edinburg, Indiana, to supply the component. Tool design in the Amos plant was supervised by Dale E. Hickey, Chief Engineer. Monsanto Lustrex Hi-Test 88, a rubber-modified high-impact styrene plastic, was specified. Delivery of the kinescope masks began three weeks after the initial order was placed. Every design requirement was met satisfactorily by custom molding the mask of Lustrex Hi-Test 88.

THE FINISHED SET. The smartly designed cabinets of the new RCA Victor* color television set are exerting great consumer appeal in showrooms across the country. Smooth finish of the fluted plastic mask harmonizes richly with the high-styling of the complete unit.

This is one of hundreds of design and production problems which have been solved by utilizing the facilities of the plastics custom molding industry. These 20th Century craftsmen are available to manufacturers designing for greater efficiency and lower costs. As a major supplier of plastic resins, Monsanto is in a position to introduce you to custom molders who will put their skills to work for you. If you are considering a design change for your product line, be sure to investigate plastics. Write to Monsanto Chemical Company, Industrial Application Dept., Springfield 2, Mass.

Investigate the completely balanced line of Monsanto styrene compounds for particular applications, sold under the trade name . . .

LUSTREX
Styrene Plastic

*RCA trademark

MONSANTO

NEW Precision in a Small Package

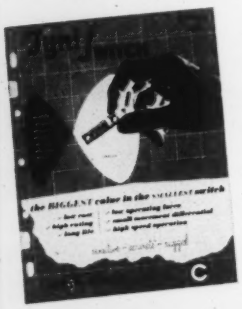
...if your Precision Snap Switch must have:

Excellent Repeatability
Low Operating Force
Small Movement Differential
High Shock Resistance
Built-In Overtravel
Virtually "Bounceless" Operation

Precision performance and outstanding contact life are features of the new TyniSwitch. Smaller than other snap switches of equal rating, it is 1⅝ inches long, 9/32 inch thick, and 7/16 of an inch wide.

Fully enclosed and extremely compact, TyniSwitch is of the simplest design. Force and movement are held to very close tolerances, and the patented blade design produces a fast and positive snap-action that is virtually "bounceless."

TyniSwitch is available in four basic designs, varying in operating force from 3 ounces up to 12 ounces in the pin operated models, and from 1½ to 12 grams in the wire operated models.



Und. Lab. Inc. Insp. 15 Amp. 125 V. AC
Canadian Standards Assoc. approved 15 Amp. 125 V. AC
Contractual approvals for U.S. Gov't applications

Bulletin 263 gives basic data and describes the designs available. Write for your copy today.

DETROIT CONTROLS CORPORATION
5900 TRUMBULL AVE. • DETROIT 8, MICHIGAN
Division of AMERICAN - Standard

Representatives in Principal Cities
Canadian Representatives:
RAILWAY AND ENGINEERING SPECIALTIES, LTD.
Montreal, Toronto, Winnipeg

AUTOMATIC CONTROLS FOR TRANSPORTATION • AVIATION • AIR CONDITIONING
REFRIGERATION • DOMESTIC HEATING • HOME APPLIANCES • INDUSTRIAL USES

—ITEM 611—

New Parts

(*Continued from Page* 185)

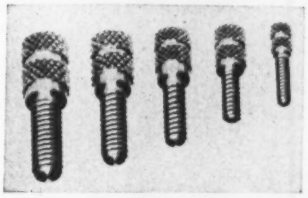
permit the gearmotors to be mounted in virtually any position. Tooth surfaces on alloy-steel gears are induction hardened for strength and wear resistance. **Reliance Electric & Engineering Co.,** 1088 Ivanhoe Rd., Cleveland 10, O.

—Circle ITEM 463

Threaded Studs

in all regular thread sizes

Threaded studs for molding in plastics, rubber, die castings or potting compounds are designed to be molded into the product at the



time of fabrication. They have a knurled head to prevent rotation

and are provided with two circular relief bands to prevent pullout. Studs are available in all regular thread sizes from No. 2 to ⅜-in., both NC and NF threads. Class 2 threads are standard; Class 3 threads are also available. Made of brass, the studs may also be made to order of steel, aluminum or stainless steel. **Standard Insert Co.,** 12270 Montague St., Pacoima, Calif.

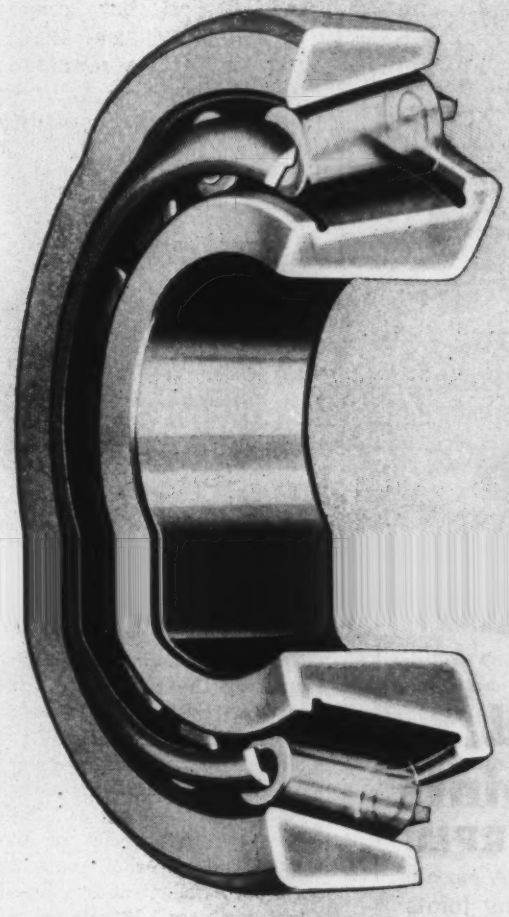
—Circle ITEM 464

High-Strength Foams

insulate and reinforce voids between structural members

Two new thermosetting, self-curing polyisocyanate foams, designated Expansible Compounds Type A and Type 1, are especially suited for filling structural cavities, such as those occurring between panels in aircraft, railroad cars and buses. Both compounds are two-part liquid formulations which, when mixed with a catalyst under proper conditions, can be foamed into place to produce a rigid cellular material that will not break loose, settle or sag. Type 1 compound produces resilient or rigid foams

There's a BOWER TAPERED ROLLER BEARING engineered to fit your product



Types and sizes to fit a wide range of tapered bearing applications

There's no need to compromise with bearings! Whatever your product, if it uses tapered roller bearings, call in a Bower engineer for expert help on selecting the exact type and size you need.

Depending on your own particular needs, he'll make sure you get the exact size and type—selected from Bower's complete tapered line—engineered to assure maximum performance in your application.

Most important of all, when you specify Bower tapered roller bearings for your product, you get all the advantages of advanced Spher-O-Honed design—less maintenance, longer life, smoother operation. Get the full facts on the *complete* Bower line.

Tapered, Straight and Journal Roller Bearings for every field of transportation and industry

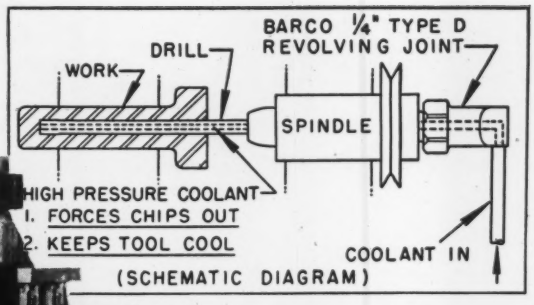
SPHER-O-HONED

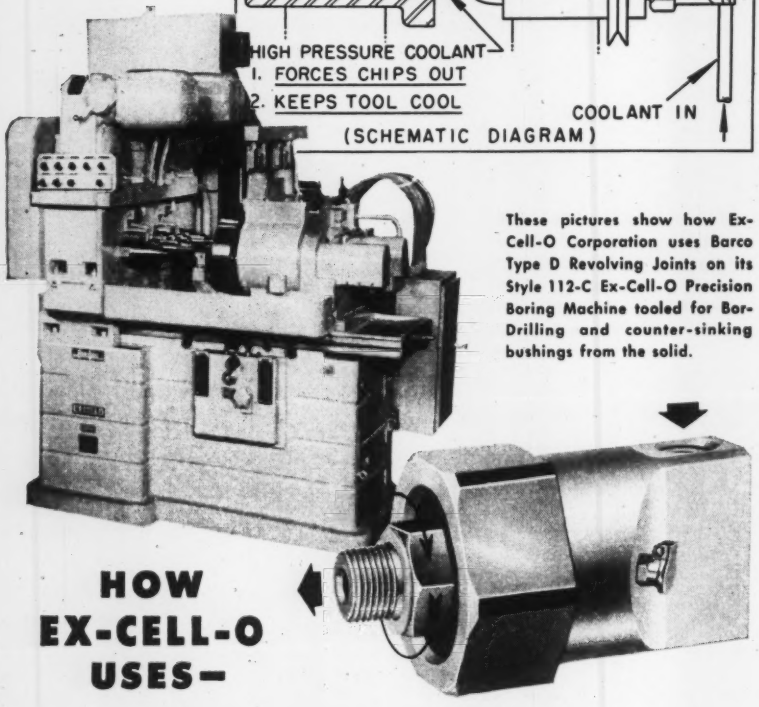
BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION • *FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICH.*

—ITEM 612—

BARCO





These pictures show how Ex-Cell-O Corporation uses Barco Type D Revolving Joints on its Style 112-C Ex-Cell-O Precision Boring Machine tooled for Bor-Drilling and counter-sinking bushings from the solid.

HOW EX-CELL-O USES—

New High Speed Barco Revolving Joints

for speeds up to 10,000 RPM

BARCO'S new, high speed Type D Revolving Joints are especially designed for machine tool installations. Ex-Cell-O Corporation uses them to introduce coolant under high pressure through the spindles and Bor-Drills of the machine shown above to force out chips and keep the drills cool (see sketch). Barco's Type D Joints are well-suited for this application because of their precision construction and compact design. Exclusive seals are self-adjusting for wear and permit operating speeds as high as 10,000 RPM on coolant service. Joints can be used on pressures to 300 psi (air) or 1500 psi (hydraulic). Temperatures from −20° to +225°F. For complete information, write BARCO MANUFACTURING CO., 506 G Hough Street, Barrington, Illinois.

BARCO

THE ONLY TRULY COMPLETE LINE OF FLEXIBLE BALL, SWIVEL, SWING, AND REVOLVING JOINTS

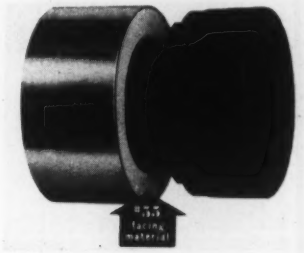
—ITEM 613—
For More Information Circle Item Number on Yellow Card—page 19

with densities from 2 to 20 lb per cu ft. Stresses required to deflect Type 1 50 per cent vary from 12 psi (2 lb foam) to 750 psi (20 lb foam). Maximum recommended continuous surface temperature is 212 F. Type A compound is supplied in formulations with 4 lb per cu ft foam density, 20 psi tensile strength, 4 psi flexural strength and 14 psi dry compressive strength. **Minnesota Mining and Mfg. Co.,** 411 Piquette Ave., Detroit 2, Mich.

—Circle ITEM 465

Facing Material

for mechanical seals



No. 55 surfacing material, developed by the Norton Co., provides a wear-resistant, high refractory coating of pure oxides. It is applicable to basic seal parts of steel, bronze, aluminum, stainless steel, monel and other alloys. Coating is resistant to thermal or physical shock and corrosion, and seals with a low coefficient of friction at contact surfaces. It retains original microfinish flatness. Recommended uses for the material include refinery, chemical and general industry processing equipment. **Duralmetallic Corp.,** 2104 Factory St., Kalamazoo, Mich.

—Circle ITEM 466

High-Speed Relay

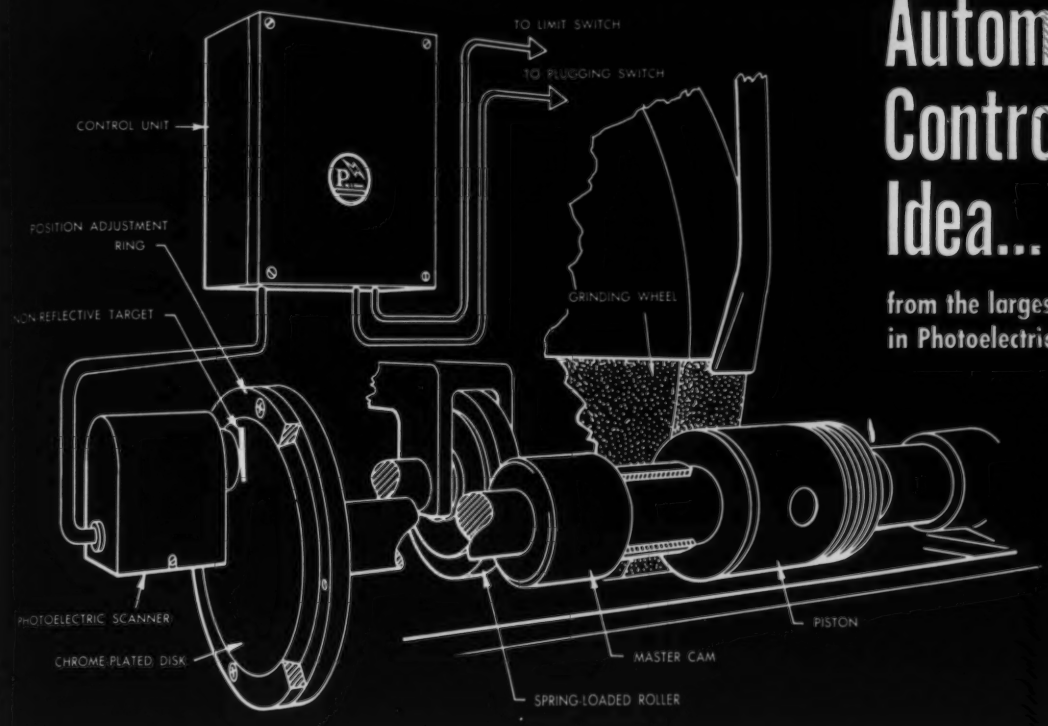
has 200 microsec pull-in time

Designed for dry-circuit and low-power applications, this Syncroverter high-speed relay has a pull-in time as low as 200 microsec (including bounce) and 300 microsec drop-out time. It is unaffected by 30 g shocks or by 10 to 55 cps vibration at 10 g. Temperature range is −55 to 100 C; contact

Another cost-reducing

Automatic Control Idea...

from the largest Specialists in Photoelectric Controls



Photoelectric Control Raises Grinder Output

Problem: To save waste motion in manually loading and unloading a piston grinding machine, by stopping the work piece in precisely the same position at the end of every work cycle.

Solution: A Photoswitch photoelectric scanner, positioned at the end of the rotating shaft carrying the piston, has its light beam focused on a chrome-plated disk that rotates with the shaft. A black target on the disk passes in front of the scanner with each revolution. During the actual grinding, the photoelectric circuit is held open, and no signal is produced as the passing target repeatedly "blacks out" the reflected light beam. At the end of the timed grinding interval, the grinding wheel is automatically backed off, and trips the limit switch that closes the photoelectric circuit. The next time the black target passes the scanner, the Photoswitch Control instantaneously actuates a plugging switch, which brakes the work-drive motor and stops the shaft at the exact desired point in its rotation.

Results: Typical work cycle shortened as much as 10%, by eliminating waste motion in loading and unloading the pistons in the accurate position required for modern "off-round" grinding.

This control design is typical of thousands of successful Photoswitch Systems for automatic electronic control of machinery and processes. In Photoswitch's wide variety of high quality photoelectric controls, liquid level controls and electronic timers, you will probably find an exact answer to your automation requirements.

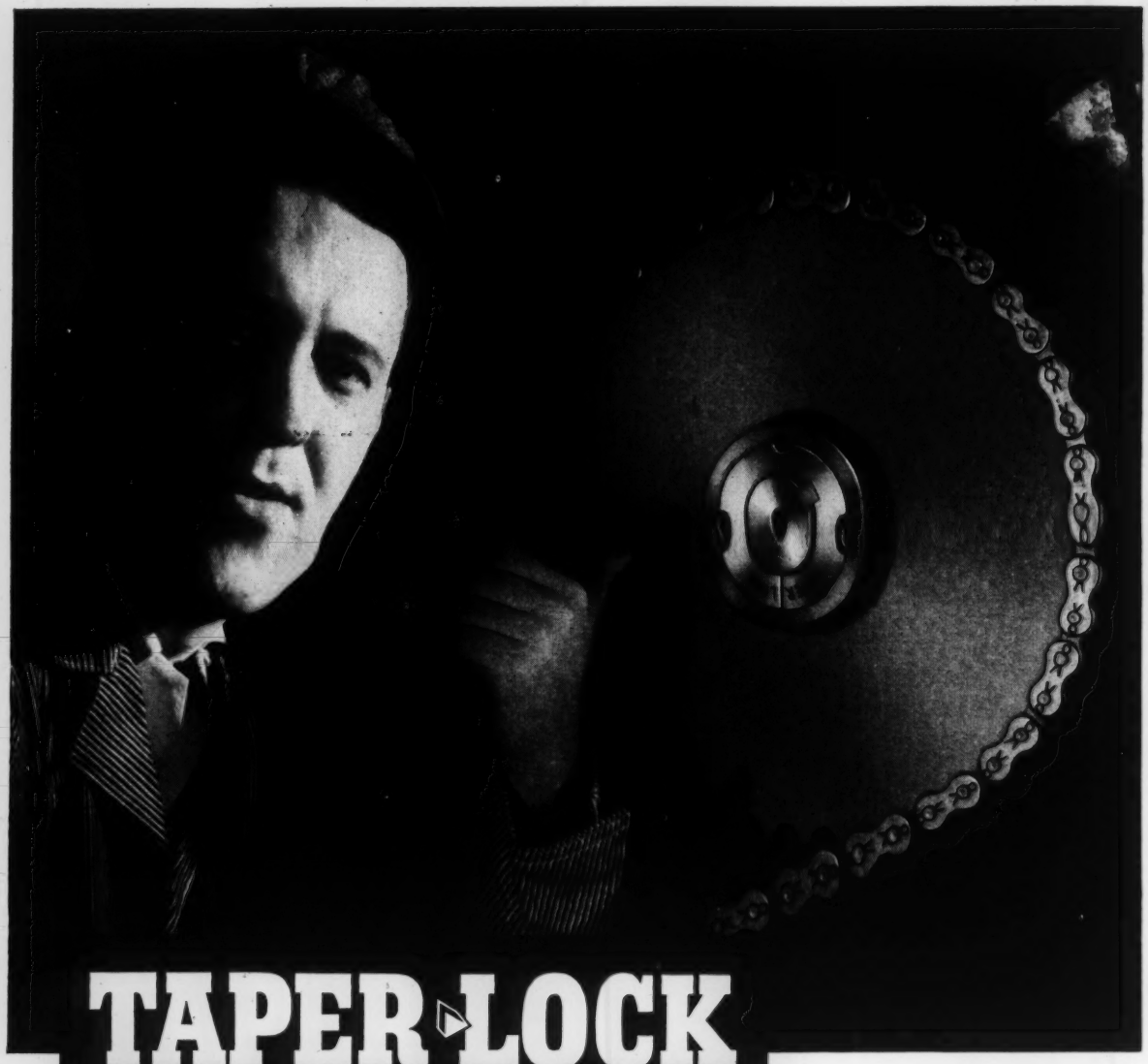
FREE — 46 more ideas — Get this 76-page book. Shows in detail how designers of machines for many different industries have employed standard packaged electronic controls. Tells how they found new opportunities to reduce costs through simplification of design . . . how they developed order-getting user advantages. Shows you how easy it is to apply Photoswitch Controls for sorting, counting, starting, stopping, inspecting, indexing, adjusting, weighing, timing, limiting, safeguarding, etc.

Photoswitch DIVISION
ELECTRONICS CORPORATION OF AMERICA
Dept. P2-6, 77 Broadway • Cambridge 42, Mass.

Send FREE copy of "Cutting Production Costs with Electronic Controls"

Name.....
Company.....
Address.....
City..... **State**.....

FIREYE DIVISION • COMBUSTION CONTROL DIVISION • BUSINESS MACHINES DIVISION
PHOTOCONDUCTOR-TRANSISTOR DIVISION • MARINE DIVISION • MILITARY DIVISION



TAPER-LOCK

A PATENTED PRODUCT OF DODGE

Holds so tight it will twist a cold-rolled shaft!

Yes, the Taper-Lock bushing really grips the shaft—holds with the firmness of a shrunk-on fit. It seats evenly along the entire length of the hub. There's no collar, no protruding part, no flange to prevent uniform compression. Having full contact with both hub and shaft, the Taper-Lock bushing holds so tight it would twist a cold rolled shaft before it let go. *Until you want to demount it!* Then a few turns of a hex wrench will release it quickly and completely, without shock to bearings or machinery. For the full story call your Distributor—or write to

DODGE MANUFACTURING CORPORATION, 3300 Union St., Mishawaka, Ind.

THERE'S ONLY ONE TAPER-LOCK, THE BUSHING THAT MOUNTS FLUSH!

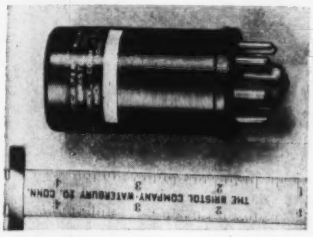
Standardize, economize with Taper-Lock, the bushing that is interchangeable in Dodge sprockets, sheaves, couplings and conveyor pulleys. *More than 2,000,000 in use!*

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified telephone directory, or write us.

DODGE

of Mishawaka, Ind.

—ITEM 615—



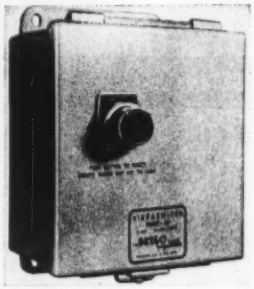
ratings are to 200 ma, 28 v; stray contact capacitance is less than 15 mmfd. Under these conditions, life expectancy is at least 1000 hr at 400 operations per second. Relays which meet nonstandard specifications are also available. **Bristol Co.**, Waterbury 20, Conn.

—Circle ITEM 467

Vibration Monitor

detects malfunctions in rotating equipment

Malfunctions, such as bearing roughness, unbalance, broken blades, or bent shafts, are detected by this vibration monitor, which either gives an alarm or shuts



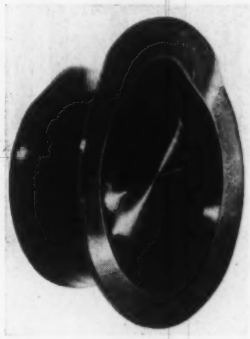
down the equipment. Detector housing meets JIC standards and is oil tight. Mechanism does not require an outside power source and is fail-safe. Adjustment range is from 0 to 2 *g*; SPDT contacts are rated at 5 amp, 115 to 230 v ac. **Beta Corp.**, Forest Ave. at Ridge Rd., Richmond 26, Va.

—Circle ITEM 468

Piston Seal

has deep-convolution flange design

Class 4 piston seal is designed for use in air and fluid-operated instruments, actuators and motors. It has a deep convolution flange design which permits easy application in many types of equipment. Primary use is in instruments and machines having natural parting surfaces between cylinder and mating metal surfaces. Seal functions mainly as a gasket, preventing leakage at the parting surface. Several Class 4 seals are available in sizes from 2.75 to 6 in. Design utilizes elastomers and fabrics such as nitrile rubber and nylon or silicone rubber and Dacron. Free-positioning, with complete relaxation at all points within the stroke,



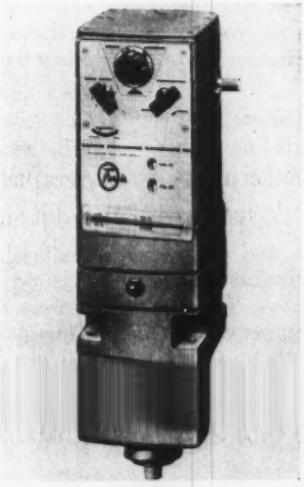
the seal is sensitive and virtually free of friction or spring gradient. **Bellofram Corp.**, Burlington, Mass.

—Circle ITEM 469

Hydraulic Governor

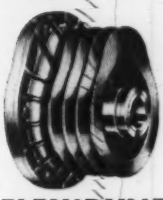
has 0.1 per cent steady-state stability

Rated work of class 3300 hydraulic governor is 123 in.-lb, rated torque is 159 lb-in. and steady-state stability is better than 0.1 per cent. Isochronous or speed-droop characteristics can be obtained by manual adjustment. Additional adjustments provided on the governor are: speed changer, first compensation relay, second compensation

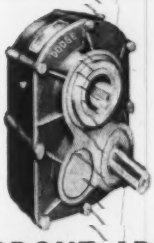


(*Continued on Page* 196)

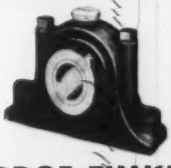
DODGE PRODUCTS you should know



FLEXIDYNE
DRIVES & COUPLINGS



TORQUE-ARM
SPEED REDUCERS



DODGE-TIMKEN
PILLOW BLOCKS

DODGE BULLETINS YOU SHOULD HAVE

- ✓ Flexidyne Dry Fluid Drives and Couplings. Complete story and selection data. Bulletin A-640-A.
- ✓ Torque-Arm Speed Reducers. Technical data and selection methods on all 14 sizes—1 to 60 hp. Bulletin A-637.
- ✓ Rolling Bearings. Load ratings, dimensions and other data on Dodge-Timken and SC and SCM Ball Bearings. Bulletin A-638.

Write for your copies.

DODGE MANUFACTURING CORPORATION
3300 Union Street • Mishawaka, Indiana

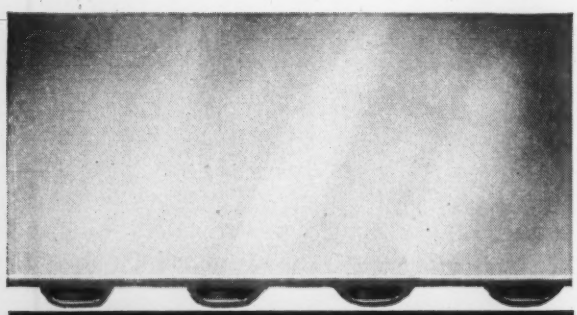
DODGE
of Mishawaka, Ind.

—ITEM 616—

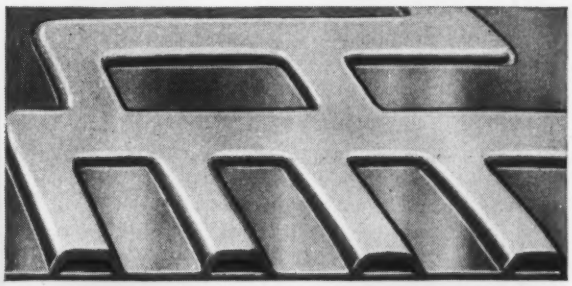
Engineers Demanded It!
Reynolds Invented It!

REYNOLDS ALUMINUM TUBED SHEET One-Side-Flat

(Patent Pending)



FLAT SIDE



PATTERN SIDE

The exciting new material to complement your design and engineering skill

Reynolds new Tubed Sheet *One-Side-Flat* is the only sheet with one flat side providing integral tubing in any parallel or non-parallel patterns no matter how complex! Tubed Sheet *One-Side-Flat* (two sheets of aluminum metallurgically bonded together so that the heat transfer passageways are *in the sheet*) is flat on one side and has the built-in tubing pattern on the other side. This amazing material routes gas or liquid wherever needed with greater freedom and greater efficiency and at lower costs.

Like the original Reynolds Tubed Sheet that has its integral tubing pattern expanded on both sides and is widely used in the refrigeration industry, this exclusive new Reynolds development is exciting interest in the refrigeration and other industries because it promises *even more advantages.*

For example, in *refrigerator evaporators,* Tubed Sheet *One-Side-Flat* permits direct contact of the flat side with food packages and ice cube trays thus speeding heat transfer, providing faster freezing. As a *skin for aircraft,* its flat side provides a smooth exterior and the entire sheet can be cooled through the integral tubing offering a possible solution to the "heat barrier" faced by supersonic planes. In *radiant heating panels for buildings,* its flat surface can be finished in a variety of decorative ways and used to face room interiors while hot water is circulating through the integral passageways on the other side of the sheet.

Why not investigate Reynolds Tubed Sheet *One-Side-Flat* for application in your industry? Whether transportation, chemical, petroleum, construction, appliance or other industry, you'll find it an intriguing new material—for amazingly flexible heat transfer use or for other uses your ingenuity may devise. For details contact your nearest Reynolds Office or write direct. *Reynolds Aluminum Fabricating Service, 2061 South Ninth Street, Louisville 1, Kentucky.*

See "Frontier", Reynolds exciting dramatic series, Sundays, NBC-TV.

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

Write for free 24-page "Catalog of Facilities". Get full details on the tremendous production facilities of Reynolds Aluminum Fabricating Service.

REYNOLDS ALUMINUM FABRICATING SERVICE

BLANKING • EMBOSSING • STAMPING • DRAWING • RIVETING • FORMING • IMPACT EXTRUDING • ROLL SHAPING • TUBE BENDING • WELDING • FINISHING

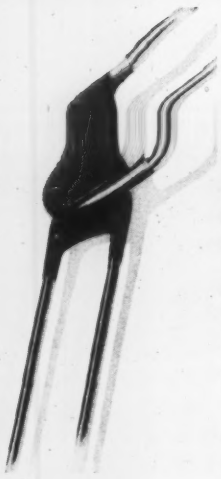
—ITEM 617—

Paragon® gives you speed . . . without fatigue!

Check the response-to-the-touch. You can actually feel the difference!

That's why the Paragon Drafting Machine noticeably cuts end-of-the-day fatigue . . . saves costly man hours . . . helps raise working standards.

See how easily protractor control ring can be reached—no matter what position your hand is in. Another time saver. Touch that ring with your *little* finger and scales rotate freely. Release pressure and scales automatically lock to nearest 15° position. And intermediate angles are just as easily set!



Top day-to-day performance is guaranteed by unique "open center" design of arms which protects smooth-working factory-set band tension.

A good look at a Paragon and a touch on that control ring is worth 1,000 words! Try it before you buy *any* drafting machine—you can *feel* the difference.

89 YEARS OF LEADERSHIP

In equipment and materials for drafting, surveying, reproduction and optical tooling . . . in slide rules and measuring tapes.

KEUFFEL & ESSER CO.

NEW YORK • HOBOKEN, N. J. • Detroit • Chicago • St. Louis • Dallas • San Francisco • Los Angeles • Seattle • Montreal

—ITEM 618—

For More Information Circle Item Number on Yellow Card—page 19

New Parts

(*Continued from Page* 193)

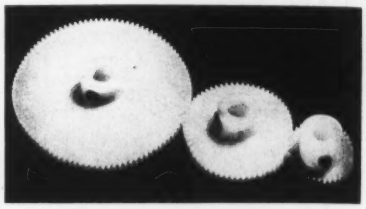
timing valve, rate of response and load-limit throttling. Speed variations are dampened by a fail-safe flexible drive. **Farris Pickering Governor Co. Inc.,** 702 Commercial Ave., Palisades Park, N. J.

—Circle ITEM 470

Spur Gears

in four pitch sizes

Nonmetallic spur gears are available in nylon (FM-10001) and linen phenolic (MIL-P-15035 Type FB1) material. Cut to AGMA Precision



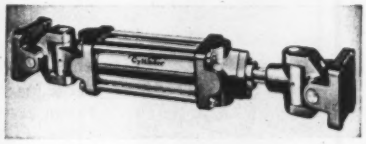
1 tolerances, they have 48, 64, 72 and 96 pitch sizes. Bores are available in ⅛, 3/16 and ¼-in. ID. **PIC Design Corp.,** 160 Atlantic Ave., Lynbrook, L. I., N. Y.

—Circle ITEM 471

Cylinder Mountings

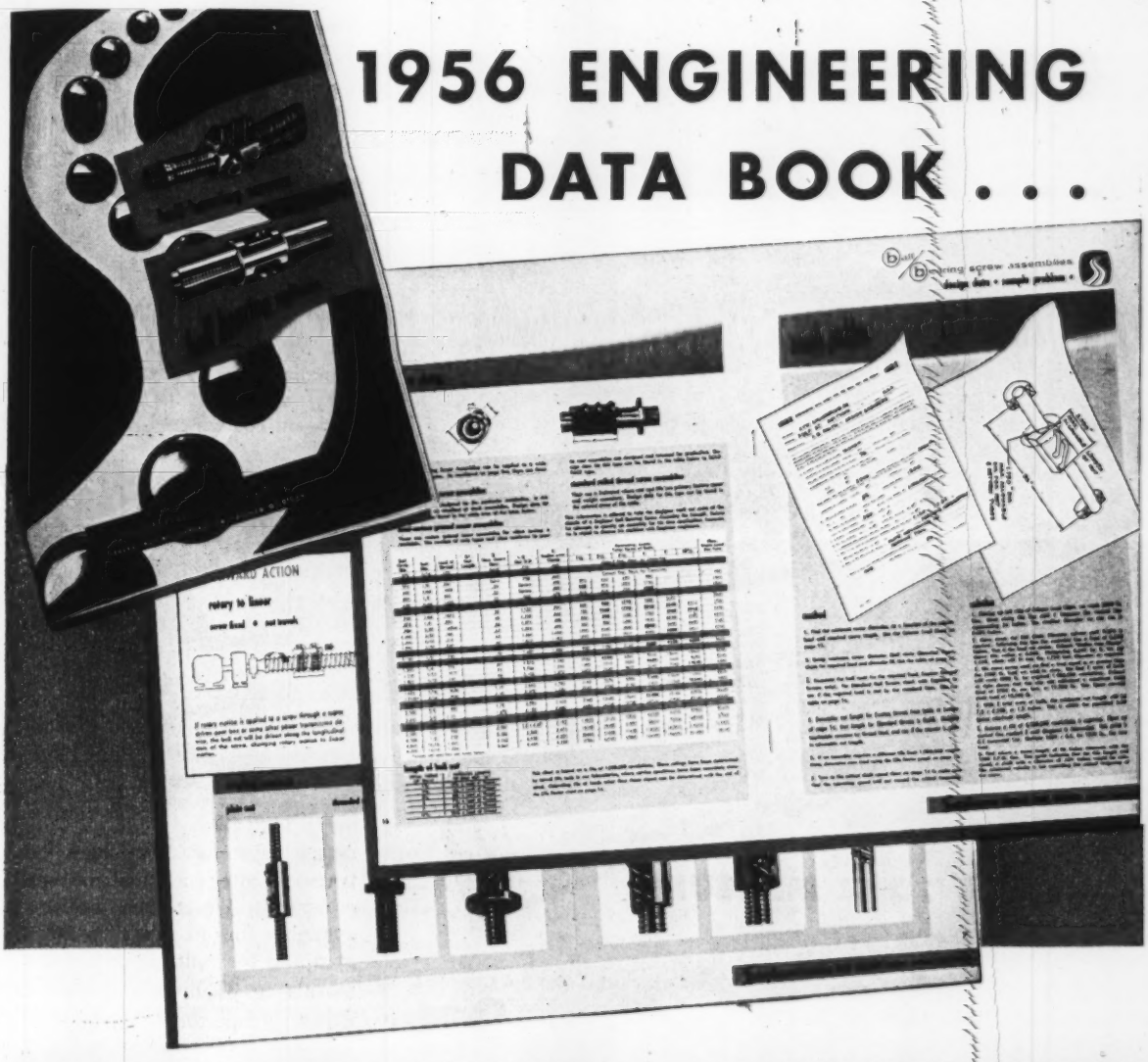
in two universal types

Universal cylinder mountings eliminate problems due to misalignment between cylinders and their loads. They are available in two forms: a hinge mount cylinder with universal mounting brackets at each end, illustrated; and a cylinder with universal trunnion and universal mounting bracket for the



rod end. Applications for cylinders with universal mountings include operation of hopper gates, elements turning about shafts such as gear segments and levers, and objects moving on wheels or tracks such as trucks or transfer tables. They also compensate for deflection and misalignment where cylinders are connected to structures that are riveted, bolted or welded

1956 ENGINEERING DATA BOOK . . .



SHOWS HOW SAGINAW b/b SCREWS and SPLINES FREE YOU FROM DESIGN LIMITATIONS OF ORDINARY ACTUATORS and POSITIONERS

BOOK CONTENTS: Principle • Types • Basic Operations • Coupling Methods • Efficiency • Versatility • Advantages • Selection Factors • Charts: Expected Life, Critical Speed, Column Load • Design Data • Sample Problem • Typical Custom Assemblies • Standard Assemblies

SAGINAW b/b SCREWS are *90%-98% efficient* (compared to 15%-20% efficiency of Acme screws). Require 2/3 LESS torque and power for same linear output—with consequent weight, space reductions. Function normally at −75° to +400° F. Two types: precision-ground or economical rolled-thread. Have been built 1½ in. to 39½ ft. long.

SAGINAW b/b SPLINES have *40 times lower coefficient of friction* than sliding splines; transmit or restrain high torque loads far better; permit vital power, weight, space reductions. Have been designed 3 in. to 9 ft. long.

Saginaw ball bearing Screws & Splines

SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP., SAGINAW, MICH.

SEND COUPON FOR 32-PAGE ENGINEERING DATA BOOK—

Saginaw Steering Gear Division, General Motors Corporation
b/b Screw and Spline Operation
Dept. 6H, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

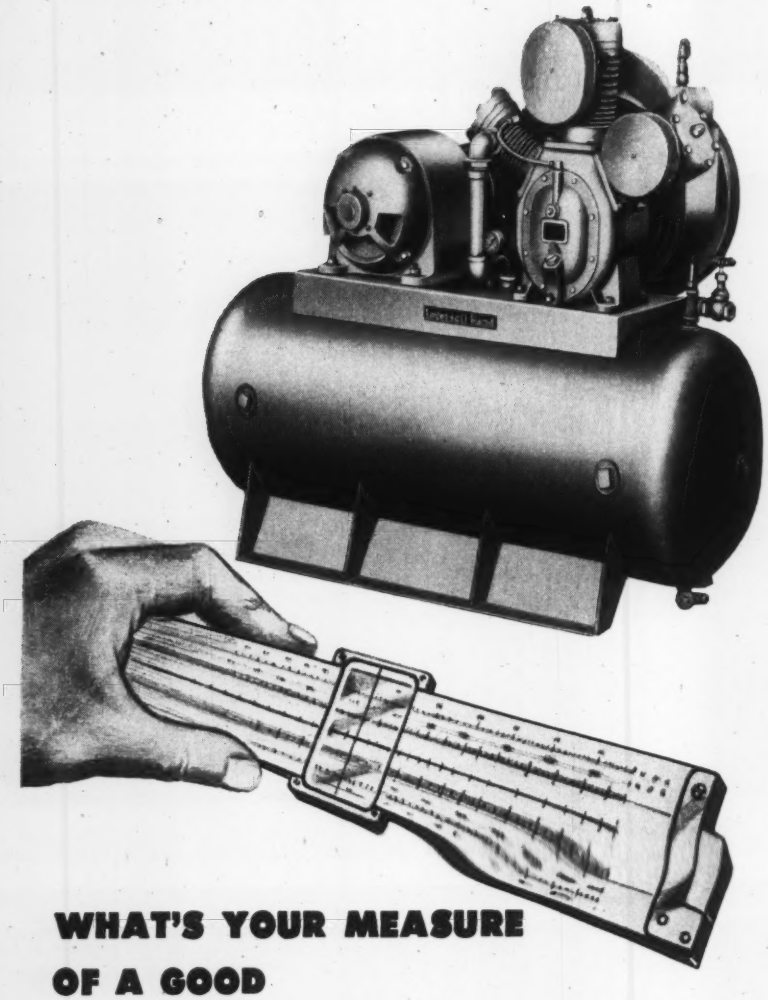
NAME_____

COMPANY_____ TITLE_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

—ITEM 619—



WHAT'S YOUR MEASURE OF A GOOD

Air Compressor?

Size for size—feature for feature—you'll do well to compare the many advantages the Ingersoll-Rand Air Compressor offers your product:

- Produces more air-per-horsepower because of design features not found in other compressors.
- Operates quietly and efficiently.
- Outlives other compressors—years longer than most as the record shows.
- Looks like Quality—and it is—compact, well constructed, durably built.

Get more detailed information on I-R Air Compressors—½ to 20 hp—and see how they can help the sale of your own equipment. For prompt response, write to:

Ingersoll-Rand

3-351 11 Broadway, New York 4, N. Y.

—ITEM 620—

New Parts

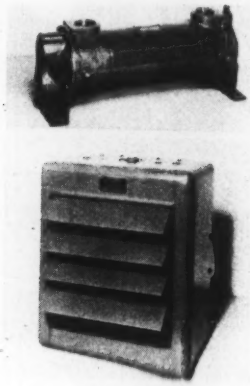
together. Four bore sizes from 1½ to 3 in. are available. **Hanna Engineering Works,** 1765 N. Elston Ave., Chicago 22, Ill.

—Circle ITEM 472

Hydraulic Oil Coolers

have high heat transfer rate

Designated series OCW (water-type) and series OCA (air-type), these oil coolers for industrial hydraulic systems have high heat transfer rates per unit of space occupied. Water-type cooler is available for oil flows up to 100 gpm and for continuous power removals to 37 hp (85 F entering water temperature). Maximum recommended working pressure is 75 psi for both water and air sides. Air-type cooler, for use where cooling water supply is limited, or where waste heat can be used for space heating, is available for oil flows to 70 gpm and power removals to 13.2 hp (based on 100 F ambient air temperature). Maximum recommended oil pressure is 150 psi. **Vickers Inc.,** 1400 Oakman Blvd., Detroit 32, Mich.



—Circle ITEM 473

Water Mixer

delivers water at 140 F

D-100 water mixer valve blends hot and cold water to produce 140 F final temperature. Factory set at this temperature, the valve is not adjustable in the field. Body is heavy forged brass, and all tappings are ½-in. IPS. Solid-type thermostatic expansion element is used, and all working parts are noncorrosive. The valve is applicable on all types of direct-fired

need quick service on TIMERS for automatic control?

Time Delay Timers

The more automatic control problems we get, the better we like it. For while it's true each automatic control job is a bit different from the rest, the record shows that our 19 years of timer experience has given us the special knowledge it takes to give you the right answers, and in near-record time.

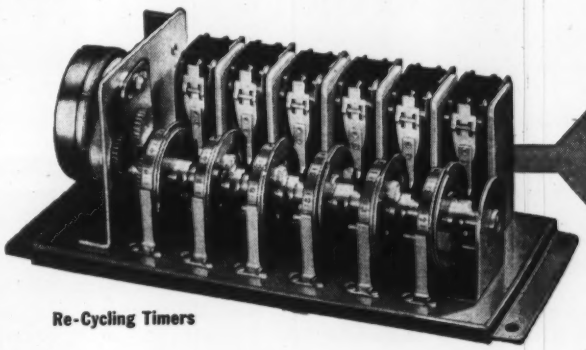
If one of our standard timers won't do your job — or one of the 721 combinations we have thus far developed from our 17 basic units — our engineers will go right to work to develop a new combination that's the one for you. That's the way we grow — and we like it.

We manufacture a complete line of timers in these 4 broad classifications:

TIME DELAY TIMERS • INTERVAL TIMERS
RE-CYCLING TIMERS • RUNNING TIME METERS

And since we maintain large stocks of our 17 basic units, we can assure you of rapid deliveries — of excellent deliveries even on special orders. So whatever your automatic control problem, you have everything to gain by submitting it to our timer specialists. They'll give you a profitable answer — almost with the speed of automatic control itself.

Interval Timers



Re-Cycling Timers

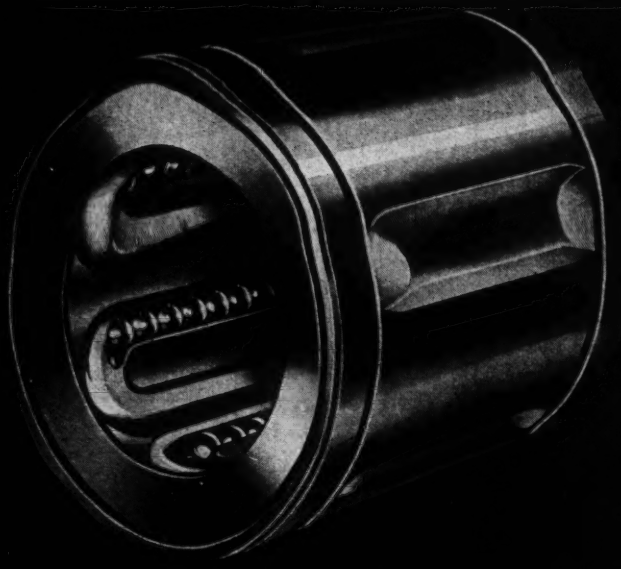
Running Time Meters

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION
1413 McCARTER HIGHWAY, NEWARK 4, N. J.

BALL BUSHING



The BALL BEARING for your

LINEAR MOTIONS

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A or Low-Cost Series B BALL BUSHINGS.

Alert designers can now make tremendous improvements in their products by using BALL BUSHINGS on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Improve your product. Up-date your design and performance with BALL BUSHINGS!

Now manufactured for ¼", ½", ¾", 1", 1½", 2", 2½", and 3" shaft diameters.

LOW FRICTION • LOW MAINTENANCE
ELIMINATES BINDING AND CHATTER
SOLVES SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

Progressive Manufacturers Use Ball Bushings —A Major Improvement at a Minor Cost

THOMSON INDUSTRIES, Inc.

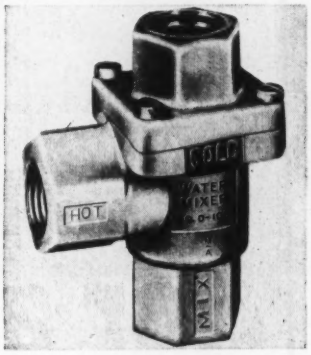
Dept. E, MANHASSET, NEW YORK

Write for descriptive literature and the name of our representative in your city.

Also manufacturers of NYLINED Bearings — DuPont NYLON within a metal sleeve—for rotation and reciprocation.

—ITEM 622—

New Parts

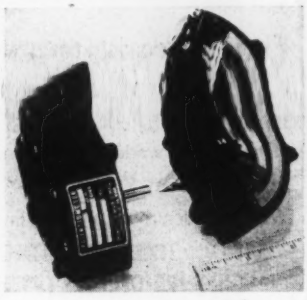


or indirect type water heaters where it is necessary to prevent excessively hot water from reaching the fixtures. It also increases heater capacity by preventing too rapid draw on the available hot water supply. **Bell & Gossett Co.**, Morton Grove, Ill.

—Circle ITEM 474

Potentiometer

has 1/17-deg resolution



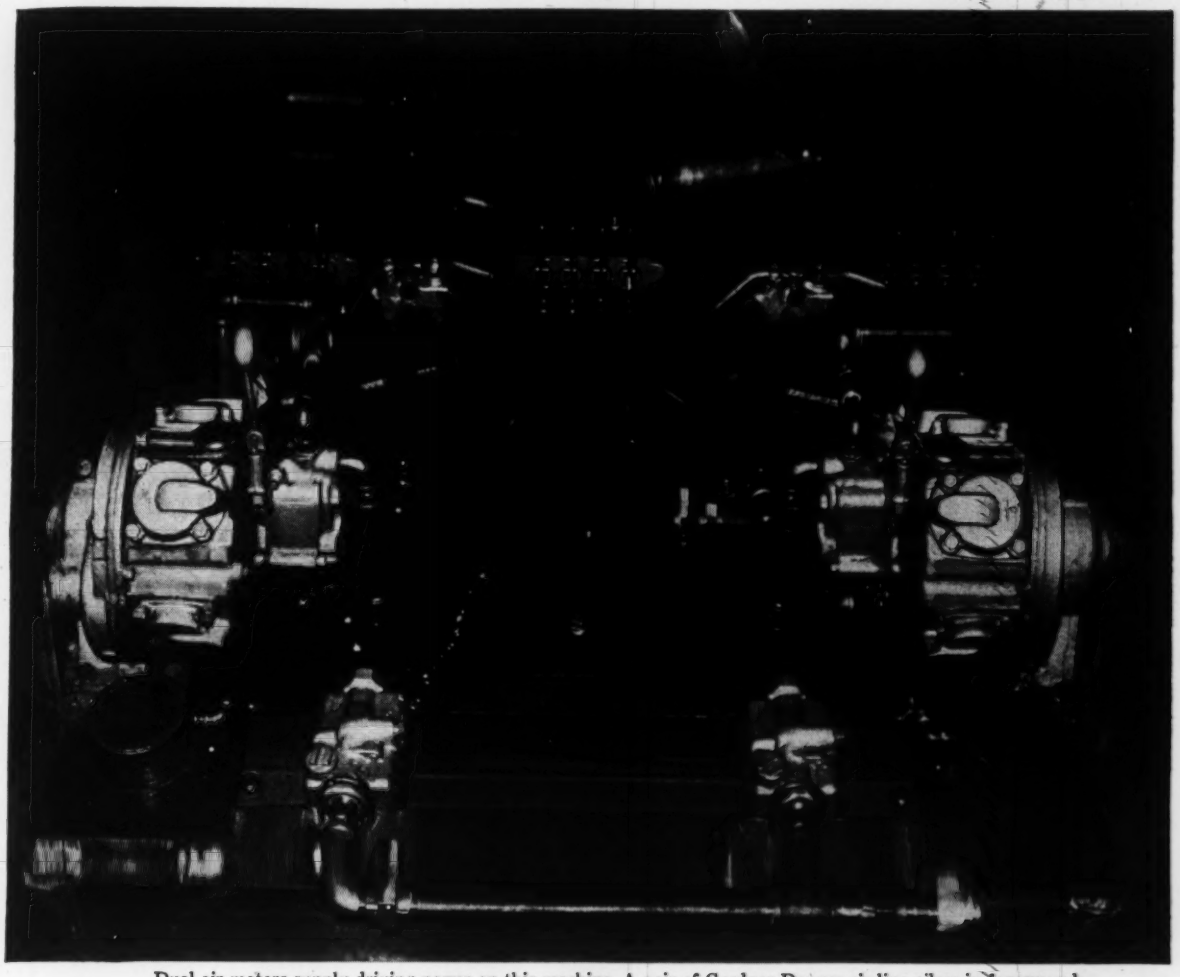
This precision potentiometer is especially adapted to flight test, servo feedback and telemetering applications. Housed in a cast aluminum case, it is designed to withstand up to 40 lb shaft side loads while operating. It is gasket and O-ring sealed against immersion to 15 psi. Other specifications include: dual element, 4800 ohms each element; dual wipers each element and pickoff; up to 2 w dissipation per element; 110 deg active travel, 5 deg overtravel each end; and resolution, 1/17-deg. **Minco Engineering and Mfg.**, 801 Eighth St. S.E., Minneapolis 14, Minn.

—Circle ITEM 475

Clamp Coupling

holds hose tightly with machined ribs and barbs

Accurately machined ribs and barbs in this Inter-Lock clamp coupling uniformly compress the hose into



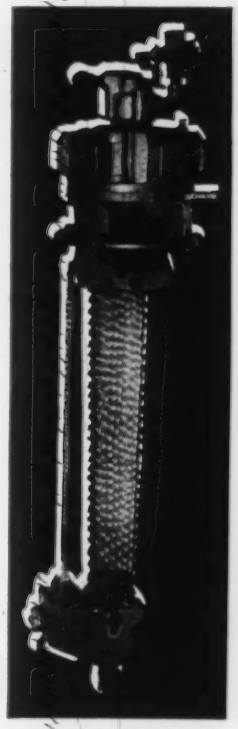
Dual air motors supply driving power on this machine. A pair of Gardner-Denver air line oilers in foreground.

Good answers to power problems
Gardner-Denver Air motors and lubricators

To the machine designer: It's nice to know a place to go when you've got pneumatic power problems. Gardner-Denver engineers will provide a solution to your application regardless of how difficult it might be. Contact our engineering staff for help in solving your air power and air line lubricating problems.

Some G-D air motor advantages:

- Unaffected by loads—will not burn out
- High torque to handle high starting loads
- Low weight to horsepower ratio
- Wide range of speeds and torques
- From 1 to 16 hp.



Air powered chain saw. Another example of a Gardner-Denver air motor at work.

GARDNER - DENVER

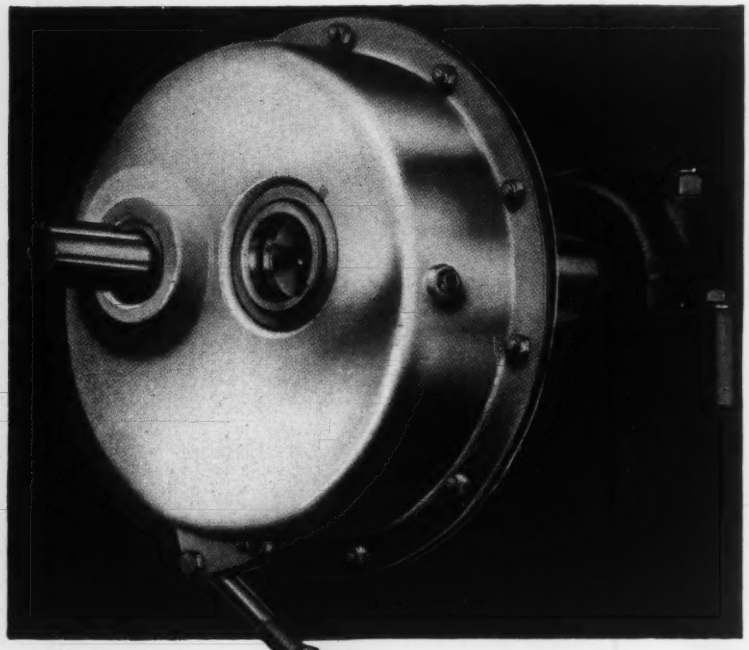
THE QUALITY LEADER IN COMPRESSORS, PUMPS, ROCK DRILLS AND AIR TOOLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

—ITEM 623—

For More Information Circle Item Number on Yellow Card—page 19



SIX SIZES

- 1/2 to 30 hp
- Single or double reduction
- Wide output speed range—420 to 10 rpm

FALK

ALL-STEEL

Shaft Mounted Drives—

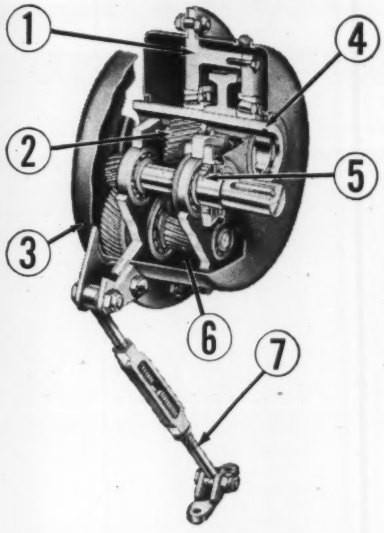
simple-compact-rugged-efficient

Created specifically for the vast number of applications demanding a sturdy and compact speed-reducing unit for direct mounting on the driven shaft, the new Falk all-steel Shaft Mounted Drive is built to give long service life at substantial savings of space, time, power and maintenance costs!

This efficient helical-gear drive, latest in the unmatched list of Falk precision-gearing achievements is an ingenious modification of the time-tested Falk Motoreducer design which has held, for more than 20 years, recognized leadership in this branch of highest-quality power transmission . . . It complements and completes the world-famous Falk line of reduction units covering the entire range of industrial applications.

Investigate the Falk all-steel Shaft Mounted Drive. Write to Department 247 for engineering bulletin, including selection and dimension details.

These famous FALK "In-built" factors *mean long life and dependability...*



1 All-steel Frame, with more than double the rigidity of iron, supports all rotating elements.

2 Precision Helical Gears, designed and machined by Falk, rated to AGMA standards.

3 Pressed Steel Housings, whose sole function is to keep oil in, dirt out; easily removed for gear inspection without dismounting unit.

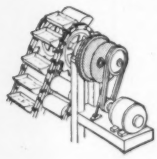
4 Through Hollow Shaft with counter bore provides for easiest installation or removal from driven machine shaft extensions.

5 Backstop can be furnished with the unit or added later for positive prevention of reverse rotation.

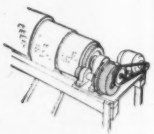
6 Positive Lubrication, continuous direct dip of revolving elements at all speeds.

7 Tie Rod and turnbuckle serve as anchor and facilitate V-belt or chain adjustment.

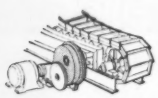
A FEW TYPICAL APPLICATIONS



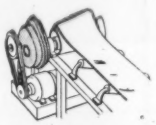
BUCKET ELEVATOR



SAND CLASSIFIER



APRON FEEDER



BELT CONVEYOR

THE FALK CORPORATION, Milwaukee 8, Wisconsin

MANUFACTURERS OF

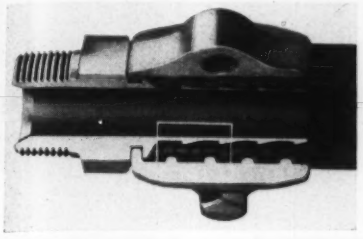
- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

FALK

. . . a good name in industry

—ITEM 624—

For More Information Circle Item Number on Yellow Card—page 19



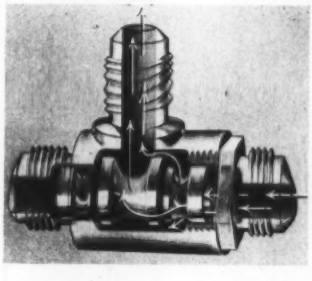
alternate recesses, providing positive grip without pinching or weakening the hose. Beveled shoulders of the barbs permit easy insertion of the insert into the hose. For use with low, medium or high-pressure hoses (5000 psi, maximum), the clamps are available for hose sizes ranging from ¼ to 2 in. ID. Inserts are male pipe, male flare or swivel female. **Eastman Mfg. Co.,** Manitowoc, Wis.

—Circle ITEM 476

Selector Valve

for vehicles with two or more fuel tanks

This valve automatically shuts off the line of an empty tank while continuing to draw from the other tank, without interrupting engine operation. It consists of three ports arranged in T-formation. Opposing ports are connected to the tanks, and port at right angle is connected to the carburetor. Between ports is a shuttle valve which automatically closes the passage on one side and opens the port on the other side when pressure is built up. If both pumps are on, pressure equalization causes the shuttle plunger to suspend half way and both pumps send fuel in part volume to the carburetor. The valve can also be used with adaptation in dual systems whereby one standby pump can be held in reserve to permit a damaged pump



(*Continued on Page 206*)

Instead of fussing around, COMPTOMETER used this camera

The gentleman with the pipe is E. F. Heitlinger, who bears the proud and simple title of Inventor at Felt & Tarrant Mfg. Co., makers of the famous "Comptometer" adding-calculating machines. The gentleman with his hand on the "go" switch of the Kodak High Speed Camera is John H. Hauptmann, Felt & Tarrant's Photographic Superintendent, 38 years with the company.

Were Mr. Hauptmann to press, the camera could take in a little over a second 4,000 successive pictures of the mechanism they are studying. Projecting the film at normal speed would then slow down action as much as 200 times. Time measurements could be recorded right on the film. The film could become a permanent record for repeated study, for patent purposes, for a sales and service training tool.

The gentlemen consented to pose for this picture because they are kindly disposed toward the Kodak High Speed Camera. Mr. Heitlinger likes it because 24 hours after the camera sang out, he had the answer to a question that he estimates would have required six weeks of fussing by a crew of four to answer through old-fashioned mechanical research methods. Mr. Hauptmann likes it because he finds that without increasing his departmental payroll he has greatly boosted the department's capacity to serve the engineers.

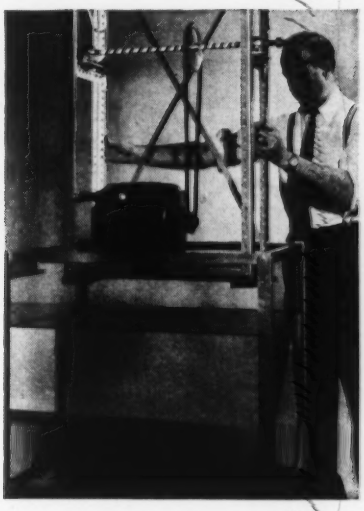
To find out more, send for the booklet, "High Speed Motion Pictures."

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

the Kodak *HIGH SPEED* Camera

Kodak

—ITEM 625—



TOMORROW:

A Standard Motor That Can Live With Water

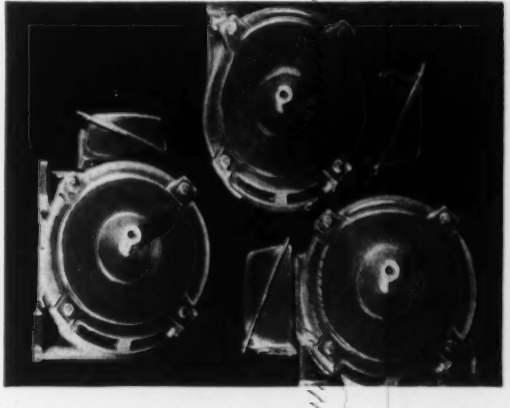
The New Life-Line A Is Another Step Closer

Today's standard motors cannot long endure the water conditions shown here. But Westinghouse is working toward a standard motor that can "live" with water like this tomorrow.

Meanwhile improved frame design, insulation and bearing protection give the Life-Line® "A" more protection than ever before. It can withstand more water and other contamination than any other motor you can buy. It's industry's closest approach to a standard motor that can operate with or within water—in any amount.

Your Westinghouse sales engineer can show you many additional reasons why the Life-Line "A" is industry's most advanced and preferred motor. Call him today.

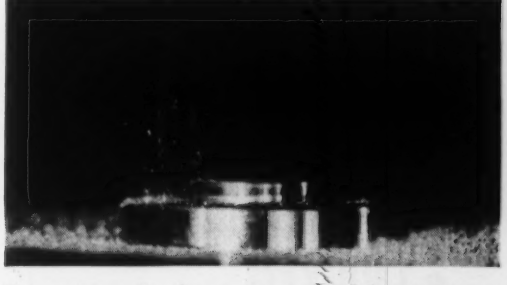
J-21924



New cast-iron frames and brackets utilize the finest grained castings with uniformly thick-walled sections precisely fitted and sealed—another reason why the Life-Line "A" is so preferred.

WATCH WESTINGHOUSE!

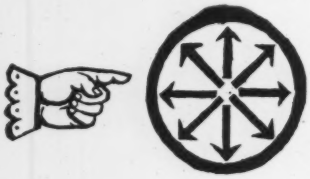
WHERE BIG THINGS ARE HAPPENING TODAY!



Two outer seals of new 4-way sealed bearing act as flingers and literally throw off damaging contaminations. Inner seals, attached to outer bearing race, are stationary and form a positive labyrinth.

Nature abhors a vacuum

but a sphere resists pressure best of all



So when you're in a vacuum for ideas—or under pressure to produce—remember a ball!

A *perfect* ball (Universal makes them to tolerances of 10 millionths of an inch!) may be the perfect starting point for the answer to your problem.

You can start rolling on a ball of almost any type metal —and move in any direction!

Yes, Universal balls offer limitless possibilities to the designer and manufacturer. They'll move with any idea.

UNIVERSAL QUALITY CONTROL— FOR ALL AROUND PERFECTION

Universal Ball co.

WILLOW GROVE
MONTGOMERY CO., PA.

—ITEM 627—

New Parts

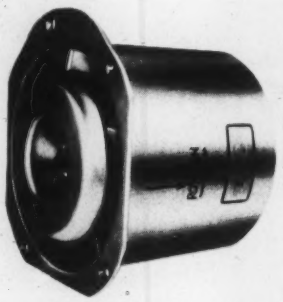
(*Continued from Page* 203)

to be removed without disturbing the operation. The valve shown is for low pressure—from 5 to 20 psi. **New Products Corp.,** 3636 Oakton St., Skokie, Ill.

—Circle ITEM 477

Fan-Blower Unit

provides 210 cfm at sea level



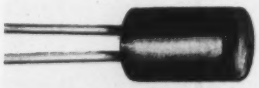
Fan-blower unit, designated BC 2914 F-1, for airborne application, is designed to provide higher flow rates at upper altitudes. It compensates for low air density by increasing blower speeds. At sea level the blower provides 210 cfm (8000 rpm) at 2 in. back pressure; at 60,000 ft blower speed is increased to 11,000 rpm. The device has a vane-axial fan with 1/6-hp ac motor, operating at 115 v, 2.5 amp, 400 cycles. Also available with a dc motor, the blower has a cast-aluminum impeller and housing. **Induction Motors Corp.,** 570 Main St., Westbury, L. I., N. Y.

—Circle ITEM 478

Photocells

have low noise level and high dark resistance

Powermaster cadmium sulphide photocells are light sensitive over the entire visible spectrum, with peak sensitivity to blue-green. They exhibit low noise level, high dark resistance and good stability. The photocells are divided into 11 sen-



When products can be designed with less material...

Have greater strength and rigidity...

Yet cost less to manufacture...

WHY

aren't more of your products designed for welded steel?

Ask

THE LINCOLN ELECTRIC COMPANY

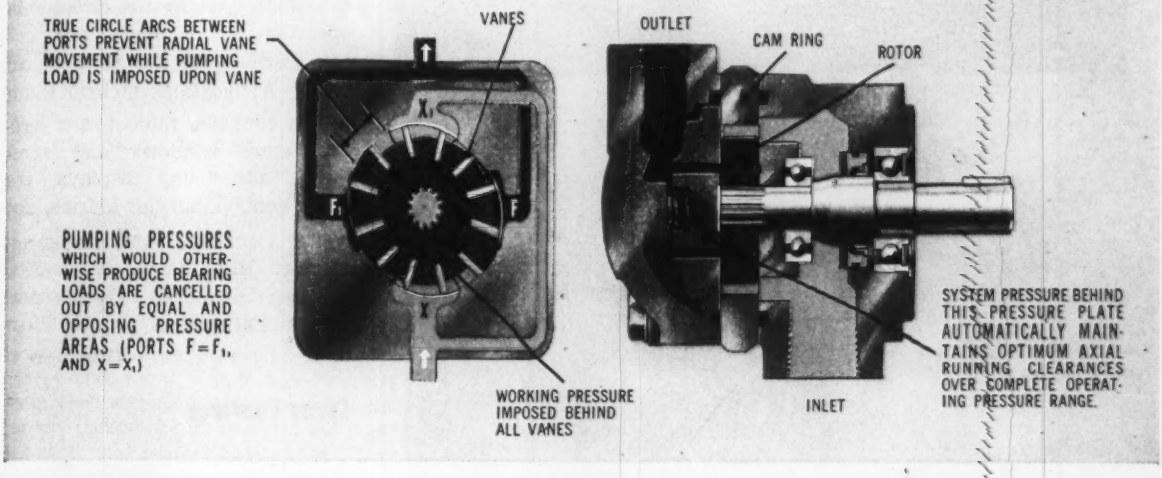
Cleveland 17, Ohio

Pioneer in Welded Structural Design ...for Lower Cost

—ITEM 628—

Question: Why are VICKERS® Balanced Vane Pumps the most widely used oil hydraulic power pumps on mobile equipment?

MILLIONS OF VICKERS VANE TYPE PUMPS ARE RUNNING EVERY DAY



Answer: Because of their SUPERIOR PERFORMANCE and MANY OTHER BENEFITS for the user.

For more than two decades, the Vickers Balanced Vane Type has held the leading position among hydraulic power pumps . . . growing steadily in popularity. The various models (only a few shown below) are *the most widely used of all pumps in oil hydraulic service on mobile equipment.*

The many advantages listed hereafter merit the thoughtful attention of anyone concerned with the selection and use of oil hydraulic pumps for construction, automotive, agricultural and materials handling equipment.

COMPLETE HYDRAULIC BALANCE—Each inlet and outlet port is balanced by another equal in size and radially opposite . . . pressure-induced bearing loads are thus eliminated.

OPTIMUM RUNNING CLEARANCES—Both radial and axial clearances are automatically maintained over complete operating pressure range and throughout pump life.

FLOATING ROTOR DRIVE—Rotor is free to float, for correct centering and alignment, on a rigidly supported spline.

TRUE-CIRCLE CAM ARCS between ports prevent radial vane movement while pumping load is imposed upon vanes. Wear between vanes and rotor is thus practically eliminated.

EASIER COLD WEATHER STARTING—At normal engine starting speeds vanes are retracted . . . centrifugal force is insufficient to throw vanes outward into operating position . . . thus no pumping action takes place and pump drag on starting engine or motor is nonexistant. Only after engine starts is speed sufficient to extend vanes and begin pumping.

GREATER INSTALLATION ADAPTABILITY—Various types of mountings and four optional positions of pressure outlet connection. By unbolting and rotating pump head, the outlet can be placed parallel, opposite to or at a right angle in either direction to inlet. Shaft drive is in either direction depending only on internal assembly. Pump can be driven by belt, chain, gear or directly coupled.

HIGHER EFFICIENCY—Tests prove exceptionally high volumetric and overall efficiency . . . not only when pump is new but also after long service.

AUTOMATIC WEAR COMPENSATION—Vanes are held in contact with the cam ring by centrifugal force and hydraulic pressure. If wear occurs, vanes revolve in a slightly larger orbit without appreciable change in performance.

TEMPERATURE ADAPTABILITY—Correct running clearances are automatically maintained which compensate for wide variation in oil viscosity resulting from temperature variation.

MINIMUM MAINTENANCE—Hydraulic balance . . . optimum running clearances . . . floating rotor drive . . . automatic wear compensation eliminate the most important causes for maintenance and repair.

LONGER LIFE—The numerous features mentioned above that keep down maintenance also contribute to longer life.

COMPACT—These pumps occupy very little space in proportion to their capacities.

CONSTRUCTION SIMPLICITY is evident from the illustrations above. This simplicity is another reason for the superiority of Vickers Vane Pumps. For further information, ask for Bulletin M-5101.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

Application Engineering Offices: ATLANTA • CHICAGO CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Summit, N.J.) • PHILADELPHIA AREA (Media) PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) SEATTLE • ST. LOUIS • TULSA • WASHINGTON WORCESTER
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

Single pump available in five basic case sizes having 15 normal delivery ratings. Operating pressures to 1500 psi (two largest units to 1000 psi).

Double pump for operating two independent hydraulic circuits from one power source. Available in 38 combinations. Operating pressures to 1500 psi (two largest units to 1000 psi).

"Package" type pump with integral volume control and relief valve, and oil reservoir; also available without oil reservoir. See Bulletin M-5107. (This pump only.)

ALL MODELS HAVE THE VICKERS ADVANTAGES MENTIONED ABOVE

7353

—ITEM 629—

NEW Furnas Electric SIZE 4 MAGNETIC CONTROL

Rated for
50 HP 220 volts
100 HP 440 volts

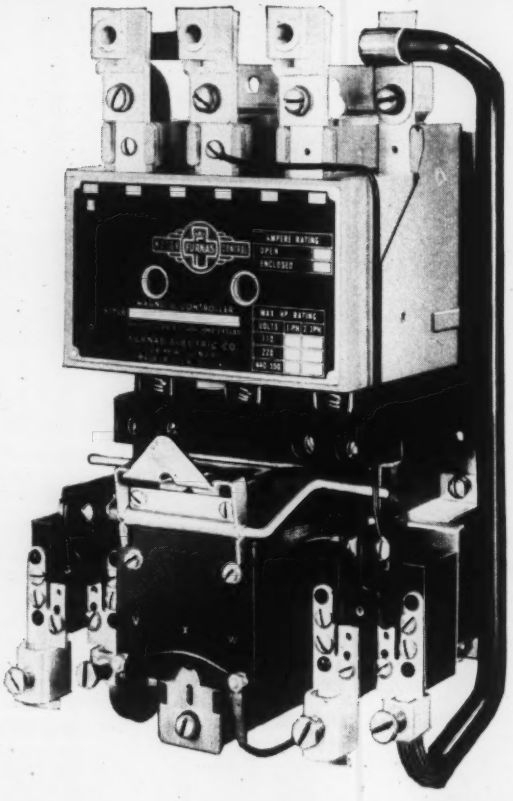
Arc Box Cover Easily Removed To Inspect Contacts

Dual Voltage Magnet Coil

All Contacts Are Easy To Replace. No Wires To Remove

Contacts Are Locked In Open Position When Reset Button Is Operated

Switchlets Easily Attached For Additional Circuits



COMPACT—STANDARD DESIGN—DUAL PURPOSE

Years of engineering and field testing are built into the Furnas Electric size 4 magnetic starter. Compare these features: COMPACT—The new size 4 starter is only slightly larger than the size 3. STANDARDIZED DESIGN—Non-current carrying elements such as magnet assembly, arc box, cross arm, mounting plate and the like are interchangeable with the size 3. This standardization has been made without compromising on life because larger contact and other current carrying parts provide the increased capacity. DUAL PURPOSE—Reconnectable dual voltage coils. A single starter stocked with its coil connected for 220 volts can be quickly and easily reconnected for 440 volts. Coil changing is eliminated and stocking of starters and coils simplified.
Write for Bulletin 5604, Furnas Electric Company, 1045 McKee Street, Batavia, Illinois

FURNAS ELECTRIC COMPANY
BATAVIA, ILLINOIS

New Parts

sitivity categories with range between 20 and 1500 mu amp at an illumination of 1 ft-c. With proper amplification, they will detect 0.001-ft-c. Low impedance cells are intended primarily for direct relay operation; high impedance cells are intended for use with an ampifier. Applications include illumination controls, radio tower lighting, store windows and street lights, advertising displays, conveyor control, burglar alarms, door control, counting and smoke detecting. **Hupp Corp.**, Hupp Electronics Div., 743 Circle Ave., Forest Park, Ill.

—Circle ITEM 479

Spray Coatings

in plastisol and organosol formulations

These sprayable dispersions are supplied as liquids which are sprayed and then heat-treated at 350 to 400 F to a tough, resilient, chemical-resistant coating. Plastisols (100 per cent solids), sprayable as supplied, provide a compound free of volatile ingredients. They can be sprayed on vertical surfaces without sagging and are available in variable degrees of gloss and in a range of colors. Uses include coating tanks, dishwasher tubs, automatic washers, phonograph turntables, cutlery trays, kitchen cabinets and similar applications. The organosols (80-100 per cent solids) provide harder films with better abrasion resistance, lower fusion qualities and adjustable viscosity control. These are used for typewriter cases, luggage, automotive paneling, steel furniture, etc. **Watson-Standard Co.**, 216 Galveston Ave., Pittsburgh 12, Pa.

—Circle ITEM 480

Potentiometers

operate with torques from 0.2 to 0.05 oz-in.

Ball bearings, ABEC Class 5, and 18-karat gold slip rings permit operation of these potentiometers with mechanical torques from 0.2 oz-in. down to 0.05 oz-in. in special cases. Designated type 18, they

What's so *different* about Ampco Metal?

It's made to last — and does!

Not by chance, either! Ampco's pioneering experience in the development and production of special copper-base alloys has resulted in strict manufacturing precautions. These and the narrow metallurgical limits, the continual controls, the best in equipment and experienced personnel are all part of the Ampco secret. Yes, they're the big reasons why Ampco alloys enjoy world-wide acceptance — why so many manufacturers insist on the year-to-year uniformity and reliability that results from Ampco's "know-how" and controlled alloy-making procedures.

And because Ampco is made to last — and does — it performs its greatest service in those applications where severe load, wear, or corrosion problems must be solved.

Here's another thing that's different about Ampco Metal: It is produced by centrifugal-, sand-, or precision-casting, shell-molding, extrusion, and forging processes — on a production basis. It's also available as sheet or plate. Your Ampco field engineer can make unbiased recommendations, because Ampco offers this complete one-source service. Call him in. Also write for Bulletin 33.

Sand castings in any size up to 14,000 pounds — and centrifugal castings up to five tons—are produced in Ampco foundries.

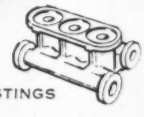
Ampco's one-source service includes production-run machining of copper-base alloys to the quality standards of the aircraft industry.

2,275-ton hydraulic press in Ampco's modern, laboratory-controlled mill for extruding rods, bars, hollow rounds, and shapes.

AMPCO METAL, INC. Dept. MD-6, Milwaukee 46, Wisconsin • West Coast Plant: Burbank, California

AMPCO®

THE METAL WITHOUT AN EQUAL



SAND CASTINGS

CENTRIFUGAL CASTINGS

FABRICATION

CAST-TO-SIZE CASTINGS

FORGINGS

SHELL-MOLDED CASTINGS

EXTRUSIONS

SHEET AND PLATE

MACHINED PARTS

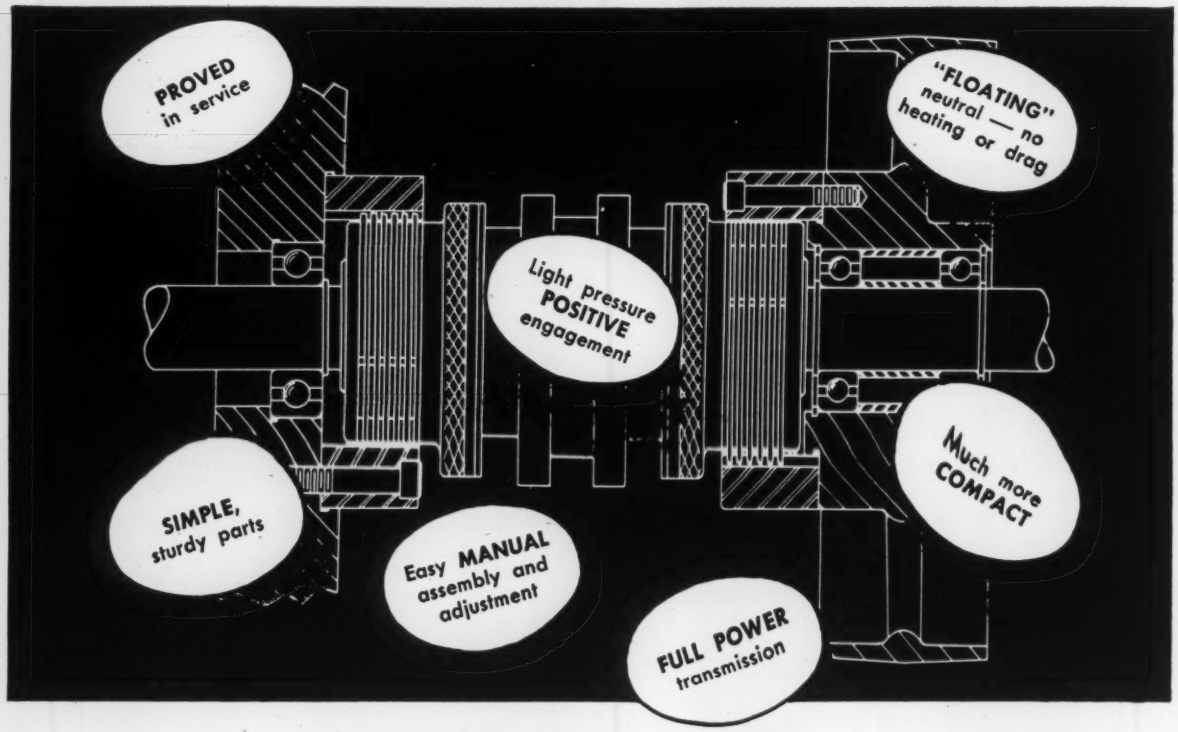
D-54

—ITEM 631—

For More Information Circle Item Number on Yellow Card—page 19

ASSURE YOUR PRODUCT THE PROVED SUPERIORITY OF A

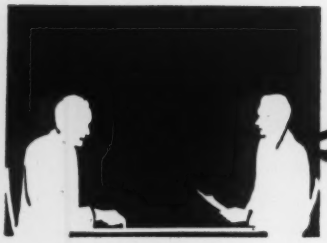
MAXITORQ floating disc CLUTCH



The line drawing shows typical application of a double Maxitorq Floating Disc Clutch, arranged for both drive and brake, with ring-type driving cups.

Such installations have a well-proved record of efficiency and freedom from maintenance. Drive and brake engagement and disengagement are smooth and positive . . . without drag or heating . . . because exclusive MAXITORQ design assures that discs ride free in neutral.

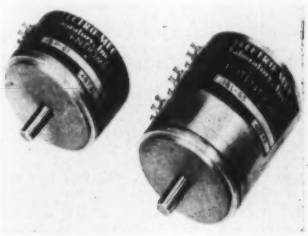
MAXITORQ Floating Disc Clutches are available in a wide range of sizes and types . . . single, double, overload release . . . to meet specific installation demands. Our engineering department also stands ready to help you solve special drive problems. Write or phone Dept. MD-6. The Carlyle Johnson Machine Company, Manchester, Conn.



Let's talk **MAXITORQ**

8CJ88

—ITEM 632—
For More Information Circle Item Number on Yellow Card—page 19



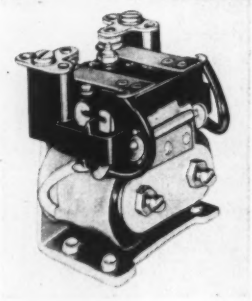
are supplied with resistance values up to 200,000 ohms. Power rating is 2.2 w at 40 C, and the toroidally wound elements provide electrical rotation to 360 deg. Standard independent linearity is 0.3 per cent; 0.1 per cent linearity can be supplied if desired. Nonlinear functional outputs and multiple taps on the resistor elements are also available. Diameter is 1.75 in. Single and three-gang potentiometers shown are 0.97 and 1.97 in. long, respectively. **Electro-Mec Laboratory Inc.**, 47-51 33rd St., Long Island City, N. Y.

—Circle ITEM 481

Plate-Circuit Relay

uses twin coils for high sensitivity

Twin coils in this model DOSY relay produce high operating forces per unit input power and effectively increase its magnetic sensitivity. Particularly adapted for use in plate circuits, it can also be used in any industrial control circuit where a signal is required



whenever control currents exceed a predetermined maximum or fall below a minimum. Contact rating at 115 v ac or 32 v dc (noninductive) is 15 amp. Relay types available are: DPDT, with 10,000 ohm or 5000 ohm coil resistances (8 ma or 11 ma pull-in currents); SPDT, with 10,000 ohm or 5000

(*Continued on Page* 214)

FILTER FORUM

New publication by Purolator is the first comprehensive filtration guide ever edited specifically for designers

Question:

Where can a designer find all the answers to his filter problems?

Where can filters be used profitably? When should they be used? How do filters save money? What are the facts about degree of filtration, flow rate, contamination to be removed, viscosity of fluid? These are questions that continually come up in design work. But, up to now, no handy, authoritative source has been available for the designer's files.

Answer:

Purolator's new "Filtration Manual for Product Designers"

Now, for the first time, Purolator's new manual gathers all the answers in one place and makes them available to the product designer. "Filtration Manual for Product Designers" spells out application considerations in detail and includes a complete glossary of terms that apply to filtration. Here are some typical section headings:

	PAGE
WHY ARE FILTERS USED	4
WHERE FILTERS ARE USED	6
PLANNING FILTRATION IN ADVANCE	8
FILTRATION ENGINEERING	10
How filters are applied	10
Glossary of filtration terms	16
How Purolator filters are made	18
WHERE THE DESIGNER CAN SELECT A FILTER	22
Gasoline engine lubrication	23
Tank and crankcase breathers	23
Air intake for engines and compressors	23
Hydraulic fluid	24
Machine tool coolant	25
Bulk fuel handling	26
Diesel engine fuel	28
Diesel engine lubrication	28
Fuel oil burner	29
APPLICATIONS THAT CALL FOR SPECIALIZED STUDY	30

PUROLATOR

FIRST in the field of filtering

MAIL THIS COUPON FOR YOUR COPY

Dept. D7-86, Purolator Products, Inc., 970 New Brunswick Ave., Rahway, N. J.

Please send me the following:

_____ Copy of "Filtration Manual for Product Designers". I'm including 25¢ to cover postage and handling.

_____ Enclosed is a description of our filter problem. How should we solve it?

NAME_____ TITLE_____

COMPANY_____ ADDRESS_____

CITY_____ ZONE_____ STATE_____

—ITEM 633—

HOW JOHNSON* MAKES A BETTER OUTBOARD MOTOR WITH ALCOA SCREW MACHINE STOCK

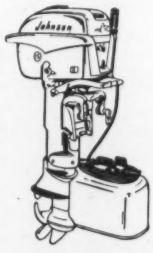
The outboard motor of 1921 was a heavy iron and brass thing that literally shook a boat to pieces. In that year, Johnson Motors and Alcoa changed the whole picture. The first Johnson Waterbug combined astounding lightness (35 pounds) with unheard-of power (2 hp) in a radical twin cylinder design. In three years, Johnson was the largest outboard manufacturer in the business.

Today, Johnson is still the largest. Its use of Alcoa® Aluminum Screw Machine Stock makes interesting reading to any manufacturer wanting to improve his product and make it sell faster.

Few products demand so much from machined parts as outboard motors—lightness, strength and corrosion resistance, too. These three advantages often set aluminum head and shoulders above other materials for screw machine parts. But consider the other advantages of aluminum which may have a more important place in your product. Exceptional machinability—limited almost entirely by machine capacity; high electrical and thermal conductivity; ease of finishing. These performance characteristics of Alcoa Screw Machine Stock, when coupled with the solid economic fact that you get three times as many parts per pound as with heavy metals, make up the total good sense of aluminum.

These are hard, commercial reasons why aluminum more than ever before should be carefully considered for every screw machine part you make or buy. Help in this type of analysis is available from every one of Alcoa's local sales offices listed in your phone book under "Aluminum." Aluminum Company of America, 873-F Alcoa Building, Pittsburgh 19, Pennsylvania.

*Johnson
MOTORS
Waukegan, Illinois



Chief Engineer, S. A. Metcalf (at right);
Ed Stoyonoff, Senior Draftsman (at left).

IN PURCHASING

Purchasing Agent, J. G. Kohler, says—"We have always used Alcoa Aluminum Screw Machine Stock and today we buy 100% of our requirements from Alcoa. We have never had a reject to my knowledge. It is this dependability of service, coupled with Alcoa technical help and Alcoa technical booklets, that keeps Alcoa strongly in our supply picture. Being the world's largest maker of outboard motors, we must schedule our buying closely to production. We know we can depend on Alcoa."

Purchasing Agent, J. G. Kohler.

IN PRODUCTION

Foreman of Automatic Screw Machine department, F. H. Mitchell, says—"We run aluminum at the top capacity of our machines. Tolerances are often as close as two-tenths. Aluminum machines so easily that we often reduce the O. D. of a part with die chasers. We also find that the cutoff finish we get with aluminum is superior to brass and steel. Tool life is fine. Tool preparation for aluminum is easy. We use Alcoa booklets as standard reference material and aluminum gives us no headaches in production. We like it."

Foreman, F. H. Mitchell (at right); James Hairrell, Machine Operator (at left).

IN DESIGN

Chief Engineer, S. L. Metcalf, says—"Our prime design consideration at Johnson is putting the most power possible in every pound of motor. For this reason we naturally rely on aluminum for over 50 screw machine parts. In addition, we have severe corrosion requirements—another reason for our use of aluminum. The fact that we get three times as many parts per pound with aluminum as with heavy metals also helps us make a better motor at lower cost. Alcoa technical help is always at our disposal. Because we use so much aluminum on our motors, we frequently have threaded aluminum parts mated with other aluminum parts. In these cases, the ease of anodizing aluminum nicely avoids any possible problems of seizure and salt water corrosion."

Typical parts made of Alcoa Aluminum Screw Machine Stock by Johnson Motors.

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

Your Guide to the Best in Aluminum Value

JOT NAME, TITLE AND ADDRESS IN THIS SPACE
TO START YOUR FREE "NELWELDER" SUBSCRIPTION

Complete photo of this Texas cowhand appears on the front cover of the July NELWELDER, industry's magazine of stud welding.

NELWELD

when you're talkin' studs..

NELSON IS YOUR BRAND

Fixin' to cut product costs? Building costs? Then round up your designers and steer them toward end welding studs to steel, NELSON style. From securing cover plates on a product to the fastening of industrial roofing and siding materials on a building, the NELWELD® method can save you big money. The studs are available in a wide range of shapes, and in sizes up to 1 inch diameter.

Corral your local NELSON field engineer, Pardner, he's a right smart hombre when it comes to studdin' around for fastening short cuts. Get on the mailing list pronto for the NELWELDER. Sign up in space above.

NELSON STUD WELDING
Division of Gregory Industries, Inc.
LORAIN, OHIO

New Parts

(*Continued from Page* 211)

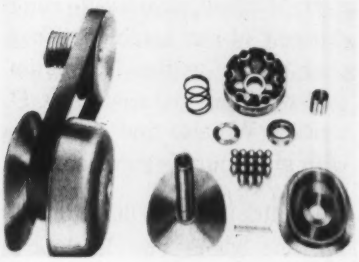
ohm coil resistances (5 ma or 7 ma pull-in currents). **Ohmite Mfg. Co.**, 3686 Howard St., Skokie, Ill.

—Circle ITEM 482

Automatic Transmission

is centrifugally operated

This automatic clutch transmission, for small vehicles, tractors, conveyors and other equipment subject to surge or peak loads, has a centrifugally operated driv-



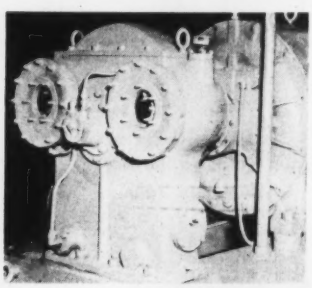
er unit and a torque-actuated driven unit. With acceleration, flanges of the driver close while those of the driven-unit open, giving a balanced drive under all operating conditions. The driver unit has an idler bearing on which the drive belt runs free when the motor is idling. Neither clutch nor gear shift are needed, the only operating controls being the vehicle throttle and brake. **Miner Pulley & Transmission Co.**, 1201 E. 58th Ave., Denver 16, Colo.

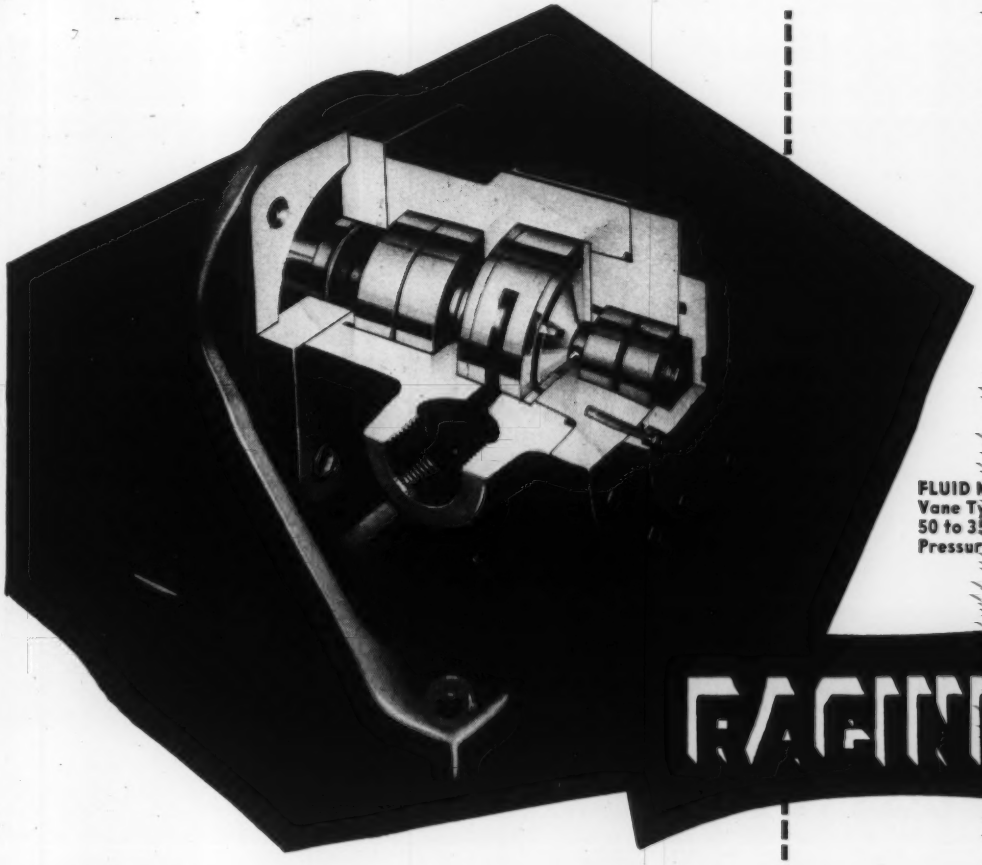
—Circle ITEM 483

Speed Increasers

have output speeds to 30,000 rpm

Designated series 4030 and 4000, these speed increasers have been designed for use in aircraft component test facilities. Series 4030 provides speed-increase ratios from 1:2.0 to 1:6.84, and power ratings





FLUID MOTOR
Vane Type
50 to 3500 rpm
Pressures to 1500 psi

RACINE®

A BETTER SOURCE OF ROTARY FORCE

Simple, compact and rugged in design, a RACINE Vane Type FLUID MOTOR transmits efficient hydraulic horsepower.

Note its simplicity and the minimum of moving parts, all of which are self-compensating for wear. Extra capacity bearings, heavy-duty shaft, tool steel vanes and alloy steel rotors, all contribute to efficient, dependable performance and maximum operating life.

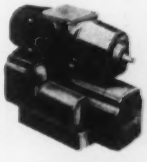
RACINE Vane Type FLUID MOTORS are available in several sizes with maximum output to 22 horsepower. Speeds from 50 to 3500 RPM — operating pressures to 1500 PSI.

Write today for full details. Let us show you why RACINE can give you "A Better Source of Rotary Force."

OTHER RACINE HYDRAULIC PRODUCTS

MODEL Q
Variable Volume
Vane Type
Hydraulic Pump

PRESSURE BOOSTER
Up to 5000 psi
Up to 7:1 pressure ratio



4-WAY VALVE
Twin Solenoid
Pilot Operated

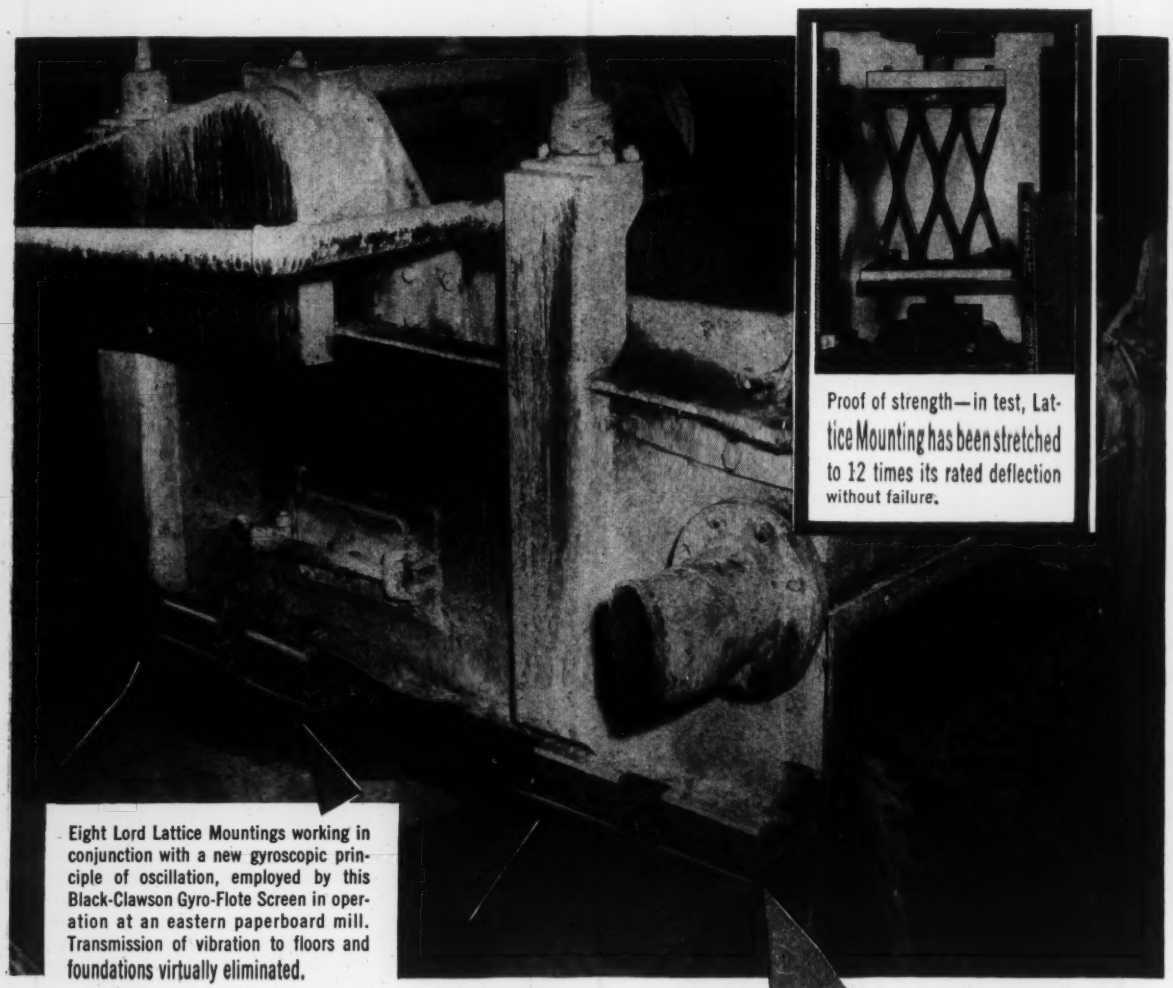
RESERVOIR
With Control Panel
Designed to your space and circuit requirements

RACINE

NFPA NATIONAL FLUID POWER ASSOCIATION

RACINE HYDRAULICS & MACHINERY, INC.
2073 Albert Street
RACINE, WISCONSIN, U. S. A.

—ITEM 636—



Proof of strength—in test, Lattice Mounting has been stretched to 12 times its rated deflection without failure.

Eight Lord Lattice Mountings working in conjunction with a new gyroscopic principle of oscillation, employed by this Black-Clawson Gyro-Flote Screen in operation at an eastern paperboard mill. Transmission of vibration to floors and foundations virtually eliminated.

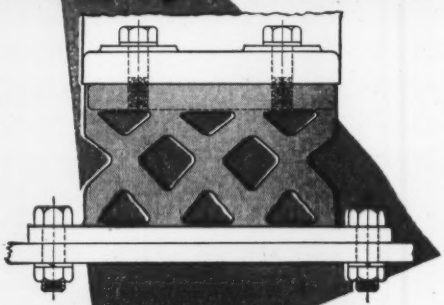
how to isolate heavy-duty machinery vibrations

LORD LATTICE MOUNTINGS PROVIDE FLEXIBLE SUPPORT—
DAMPEN LOW FREQUENCY, HIGH AMPLITUDE VIBRATIONS

Efficiency-destroying machine noise and vibration can be effectively reduced by using LORD Lattice Mountings. Placed under vibrating machinery, they absorb intermittent or continuous pounding, protect performance. Installation is a simple bolting operation using tapped holes in the upper plate and through holes in the lower plate of the unit.

The patented lattice design of the flexing element, perfected by LORD research and engineering, provides soft spring rate characteristics in all directions with good horizontal stability. This element is permanently bonded to steel plates, forming a simple, one-piece unit that *never* requires maintenance.

LORD Lattice Mountings are available in load ratings from 250 to 3,000 pounds per mounting. A complete description is contained in Bulletin No. 701. For your copy, or other information, contact your nearest LORD Field Engineer or write the Home Office, Erie, Pennsylvania.



Installa[illegible]Lattice Mountings pr[illegible]but rugged base for heavy p[illegible]pment. Installation of long-lasting Mountings is easy and quick.

LORD
BONDED RUBBER

designers and producers of bonded rubber products

since 1924

NEW YORK, N. Y. - Circle 7-3326 • PHILADELPHIA, PA. - LOcust 4-0147
CLEVELAND, OHIO - SUperior 1-3242 • DAYTON, OHIO - MIchigan 8871
DETROIT, MICH. - TRinity 4-2060 • CHICAGO, ILL. - MIchigan 2-6010
DALLAS, TEXAS - RIverside 3392 • LOS ANGELES, CAL. - HOllywood 4-7593
"In Canada—Railway & Power Engineering Corporation Limited"

Lord Lattice Mountings are covered by U. S. Patent Nos. 2322193 and RE22280.

LORD MANUFACTURING COMPANY • ERIE, PA.

—ITEM 637—
For More Information Circle Item Number on Yellow Card—page 19

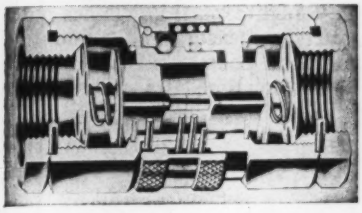
to 200 hp at 12,000 rpm maximum output speeds. Series 4000 provides ratios from 1:1.0 to 1:5.9, and power ratings to 50 hp at 30,000 rpm. Model 4030 is available with one or two output shafts, stub-shaft or aeronautical accessory spline drive. All models are forced-flow lubricated. **Snow-Nabstedt Gear Corp.**, 251 Welton St., Hamden, Conn.

—Circle ITEM 484

Coupling

for acid, alkali, solvent and steam lines

HK quick connect-disconnect coupling for fluid transfer of acids, alkali, solvents and high-pressure



steam is limited in use only by the ability of the Teflon nipple and valve seals. It functions through a temperature range of −100 to 500 F and can be subjected to lower and higher temperatures for short periods. Manufactured from solid bar stock, the coupling is furnished in 303 and 316 stainless steels, brass, aluminum, special carbon steel or any machinable material. It is available plain or with automatic shut-off valves incorporated in either or both ends. Sizes are ½ through 3 in. ID with any type end connection. **Snap-Tite Inc.**, 201 Titusville Rd., Union City, Pa.

—Circle ITEM 485

Tie Rod Assemblies

for aircraft use

Two types of stainless steel bellows tie-rod assemblies for the pneumatic ducting systems of turbojet and turboprop aircraft are used to control thermal growth of ducting systems by absorbing relative movements between two

(*Continued on Page* 220)

Accurate

CREATES a Spring . . .

This is an Accurate Spring! It's different than the rest, because it's *designed* and *engineered* for its job. It has been *created* by Accurate's skilled craftsmen who approach all spring problems with experience . . . and imagination.

When YOU need the best of springs, held to the closest tolerances and manufactured at the lowest cost—YOU need Accurate!

Accurate Springs

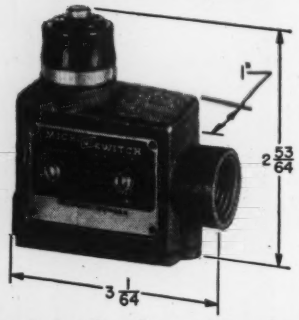
ACCURATE SPRING MANUFACTURING COMPANY
3824 West Lake Street • Chicago 24, Illinois

SPRINGS
WIRE FORMS
STAMPINGS

—ITEM 638—

Uses Unlimited for

3 switches control functions of precision grinder



Rugged day-in, day-out service to precision-grind 380 piston assemblies an hour demands components of the utmost long life and dependability.

Designers of the centerless grinding machine which performs these operations chose three MICRO SWITCH precision switches to signal and control the various steps of the loading and unloading cycle.

This selection, they told us, was because:

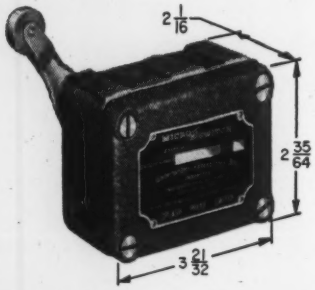
MICRO SWITCH provides the largest selection of oil-tight switches of the type required.

MICRO SWITCH national distribution makes switch replacement a simple matter.

MICRO SWITCH field engineering service is quickly available.

Switches perform 3 different functions in rotary cutter-winder

Small, compact, well-protected switches were required by the designers of a rotary cutter-winder used in the textile industry.



Each switch performs a separate and distinct function. The MICRO precision switches were selected because of their ability to best meet these diverse requirements:

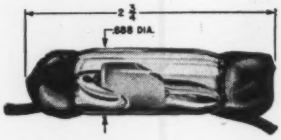
A switch (shown) prevents operation of the cutter frame if the new shell is not in position.

Another switch, which has high inrush capacity, operates the starting motor.

A ruggedly housed switch operates a 4-way solenoid pneumatic valve to raise and lower the cutter frame.

Mercury switch gives alarm protection for plant windows

A company which supplies plant protection services found HONEYWELL mercury switches ideally suited to their design requirements.



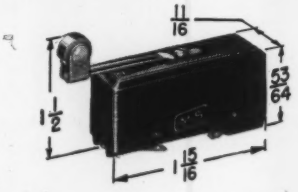
The switch is attached to horizontally pivoted windows of the fenestra or projected type.

When the window is closed, the switch is in the normal or protected position. Opening of the window activates the mercury switch and causes the alarm to be sounded at a central station.

These versatile switches perform excellent service in a wide variety of applications where tilt motion is present and low operating force is desired. Often the proper tilt motion can be developed by consultation with MICRO SWITCH engineering service.

24 switches of 8 different types control robot washer operation

Design engineers chose MICRO precision switches to control every step of a fully automatic commercial



washing machine. 24 switches of 8 different types control the measurement of water, temperature, timing of washing cycle, steam injection and dumping water at cycle's end.

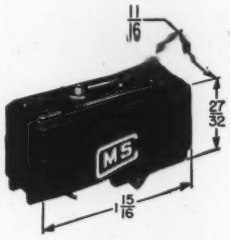
MICRO SWITCH units were selected because of their long-life, dependability, and high electrical capacity. Their use was an important factor in making possible this completely automatic washer.

MICRO SWITCH ability to provide a wide range of switch types to meet every switch requirement is the reason design engineers rely on MICRO precision switches as components for new and improved products.

MICRO SWITCH gives "push button" operation to coffee brewer

Four MICRO precision switches help provide precise control of every brewing factor of a well known commercial coffee maker.

These high capacity switches automatically measure the amount of water and control the temperature and infusion time. All switches handle high inrush current.



Designers of the coffee brewer picked MICRO SWITCH units for this device because of their ability to meet the requirements of:

Long-life reliability
Quick, positive action
High electrical capacity

Let MICRO SWITCH Engineering Service be your short cut to better design

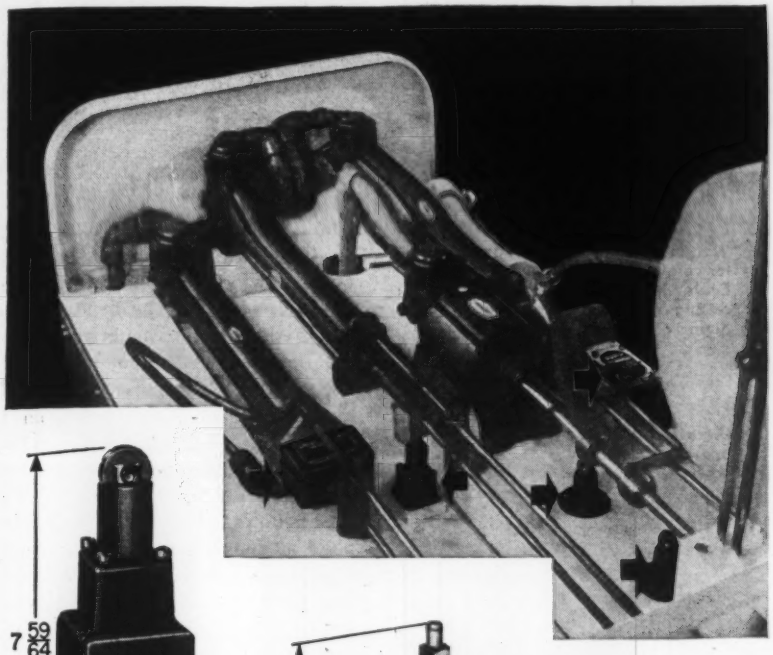
MICRO SWITCH Engineering Service is made up of experts on just one thing —precision switching problems.

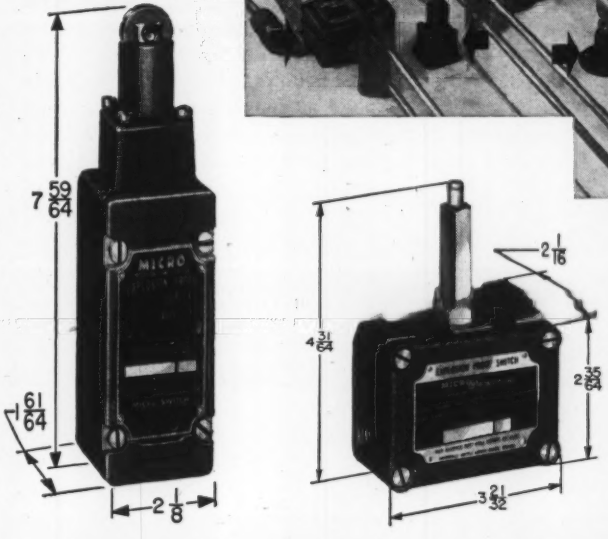
Whatever your design problem, its solution may easily be expedited by consultation with an engineering service that has helped in the solution of many complex electrical switching problems.

MICRO SWITCH may have already solved a problem similar to yours—for somebody else. Should your problem turn out to be entirely new, MICRO SWITCH can—and will—develop the switch you need.

MICRO *precision switches*

...THEIR USE IS A PRINCIPLE OF GOOD DESIGN





9 Explosion-Proof Switches Control Machine Making Shell Primer Bodies

MICRO SWITCH explosion-proof switches—of two different types—enable this ingenious machine to prepare primers, under hazardous atmospheric conditions, for artillery shells.

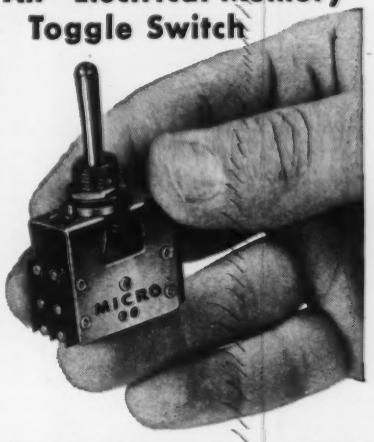
In one streamlined operation, all handwork is eliminated as this diaphragming machine lacquers the interior of the primer body; punches and forms diaphragms from a paper roll; seats diaphragms to proper depth and provides final inspection of finished parts.

Shown here is the rotary index table which is controlled by MICRO SWITCH explosion-proof switches. Five of the nine switches used may be seen.

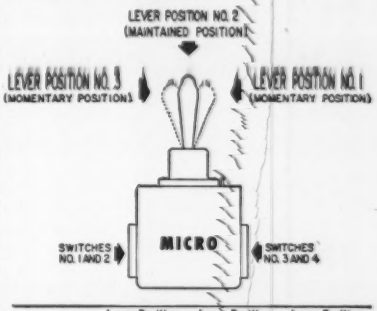
This is a typical example of the important part played by MICRO SWITCH products and MICRO SWITCH engineering service in the development of automatic machinery to serve a wide range of industrial applications.

NEW!

An "Electrical Memory" Toggle Switch



Here is the first in a new series of "electrical memory" toggle switches. It is a four-pole assembly with one pole to indicate which circuit was last operated. It promises to simplify and perhaps revolutionize some basic circuit designs of complicated ground radar units, computer devices, aircraft control panels and other types of remote control equipment.



	Lever Position No. 1	Lever Position No. 2	Lever Position No. 3
Switch No. 1	N.O. To C. Circuit Made	N.C. To C. Circuit Made	N.C. To C. Circuit Made
Switch No. 2	N.O. To C. Circuit Made	N.C. To C. Circuit Made	N.C. To C. Circuit Made
Switch No. 3	N.C. To C. Circuit Made	N.C. To C. Circuit Made	N.O. To C. Circuit Made
Switch No. 4	N.C. To C. Circuit Made	*	N.O. To C. Circuit Made

*N.C. To C. Circuit Made if Lever Last Moved To Lever Position No. 1
*N.O. To C. Circuit Made if Lever Last Moved To Lever Position No. 3

The assembly uses three single-pole, double-throw functional basic switches and one single-pole, double-throw "memory" switch.

In application the "memory" switch indicates through a pilot light or buzzer which circuit was last operated.

The three functional switches operate at three lever positions: maintained center and momentary from each extreme position.

Electrical rating of basic switches: 5 amperes 125 or 250 volts a-c. The d-c rating at 30 volts: inductive—3 amperes at sea level and 2.5 amperes at 50,000 ft.; resistive—4 amperes at sea level and 4 amperes at 50,000 feet; maximum inrush—15 amperes.

Send for new Catalog 83 on Industrial enclosed switches.

For more complete information on this new switch or any MICRO SWITCH *precision switch, contact the branch near you.*

MICRO SWITCH

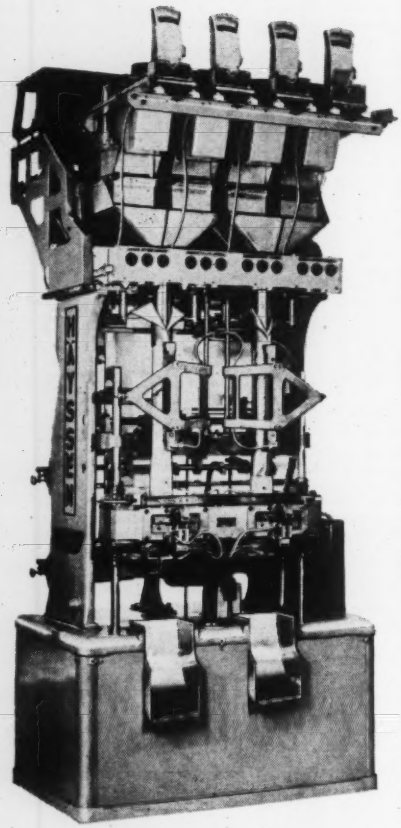
A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

—ITEM 639—

For More Information Circle Item Number on Yellow Card—page 19

Exact Weight Scales Control Accuracy in Hayssen Packaging Machine



*Weighing is against a sealed counterweight for the desired amount. Scale beam equipped with easy setting, self-locking poise for fractional ounce weight setting.

*Clearly visible scale indicators give operator a constant, visual check on each scale's accuracy while complete unit is in operation.

*Precision, even lever (1:1 ratio) scales assure minimum maintenance of weighing mechanism.

The EXACT WEIGHT Scales, incorporated as original equipment on the Hayssen, Model "F" Compak Automatic Packaging Machine, control each filling operation with extreme accuracy. Product is fed into a weigh bucket mounted on the scale lever. When the scale balance moves within approximately ½ ounce of specified weight, the fast feed is cut off and the trickle feed continues until it is shut off at correct weight.

The EXACT WEIGHT Net Weigher, (shown right), is available to original equipment manufacturers for incorporation into high speed filling and processing machines.

This Net Weigher is comprised of a precision scale with over-and-under visible indicator; stainless steel, air operated net weigh hopper and dump mechanism. Electric air valve and single or double mercury magnetic cutoff controls. Write for specifications and descriptive brochure.

Over 800 EXACT WEIGHT models of mechanical, electrical and electronic scales.

Exact Weight Scales

Better quality control

Better cost control

THE EXACT WEIGHT SCALE COMPANY

923 W. Fifth Avenue, Columbus 8, Ohio

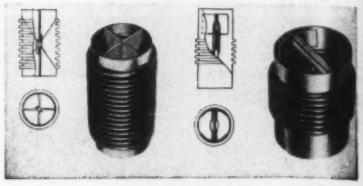
In Canada: P.O. Box 179, Station S, Toronto 18, Ont.

—ITEM 640—

For More Information Circle Item Number on Yellow Card—page 19

New Parts

(Continued from Page 217)

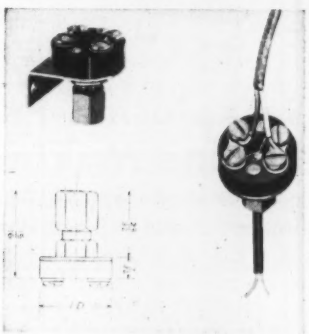


points by angular deflections. They are internally restrained and require low deflection force. The assemblies reduce the bending moments and reaction loads at mounting flanges and column loading of the ducting. Both assemblies are available in all diameters from 1 to 15 in. Center-link or single-pivot tie rod anchors the ends of a bellows at a single point along the bellows center line. Double-pivot or double-link tie rod employs two pivot points on the bellows center line to anchor the ends, and is capable of absorbing some lateral offset. **Arrowhead Rubber Co.**, Metal Products Mfg. Div., Long Beach, Calif.

—Circle ITEM 486

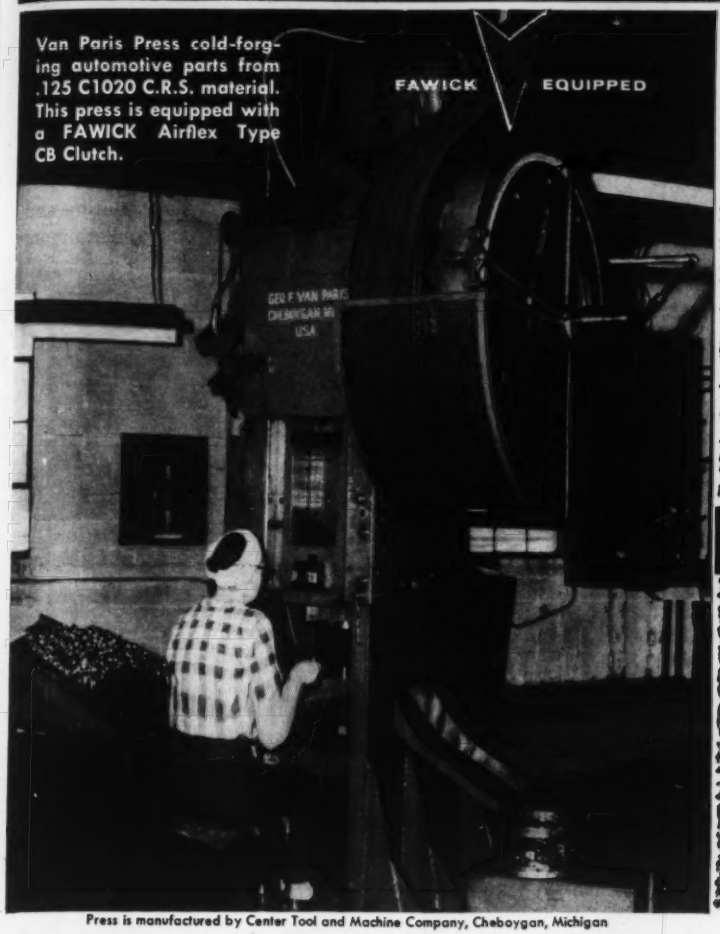
Miniature Thermocouple Head

withstands 500 F temperatures



This miniature screw-type connection head for thermocouples, electric heating elements or magnesium oxide insulated conductors, is made in two models—plain and with angle bracket. Operating temperatures range up to 500 F. Stem sizes accommodated are 1/16, ⅛, 3/16 and ¼-in. These units provide a screw-type connection between small-gage thermocouple wires and large-gage lead wires. Stress and vibration of the conductor is eliminated by transferring the load to stem or bracket. Connector fastens to the stem by

IN THE METALWORKING INDUSTRY



Van Paris Press cold-forging automotive parts from .125 C1020 C.R.S. material. This press is equipped with a FAWICK Airflex Type CB Clutch.

Press is manufactured by Center Tool and Machine Company, Cheboygan, Michigan

The famous FAWICK Airflex Type CB Clutch element used on Van Paris presses.

Typical automotive part cold-forged on Van Paris Press.

doing small press jobs in a BIG way!

HERE'S WHAT ONE FAWICK-EQUIPPED VAN PARIS PRESS IS DOING:

Operation—Cold-forging automotive parts from .125 C1020 C.R.S. material.

Product Rate—1800-2200 single trips per hour

Production History—18 months, and over 6 million 150-ton blows without interruption

Maintenance—None required

HERE'S WHAT FAWICK CLUTCHES CONTRIBUTE:

Lower Original Press Cost—through use of FAWICK standard packaged parts.

Faster Clutch Action—permitting exceptional single trip operation

Minimum Maintenance Cost—by greatly reducing down-time for wear adjustments or lubrication

Overload Protection—for machines and dies against double blanking, etc.

Exceptional, Smooth Press Control—for more accurate high speed work

Less Operator Fatigue—through instant-acting remote controls

These are typical of the advantages FAWICK Clutches, Brakes, and Controls will produce on your specific equipment. The nearest FAWICK representative or the Home Office will be glad to show how simply this can be done.

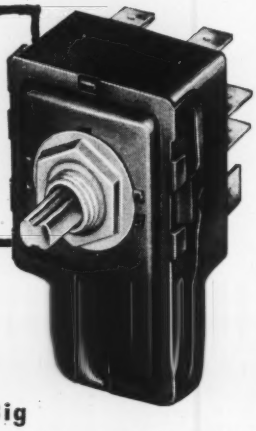
Call or write today and you'll find out why "IT OPERATES BEST WHEN FAWICK-EQUIPPED".

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
In Canada: Fawick Canada, Ltd., Toronto, Montreal

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES

This Little Switch Goes to Market

. . . in air conditioners, fans, unit heaters, appliances, motor and resistive circuits.



This Little Switch Is Big

Ratings range up to 25 A. at 120 or 240 V., and ½, ¾ and 1 hp at 120 V. and 2 hp at 240 V., A.C. U.L. Approved. (Small D.C. ratings also available.) *But base is only* 1½" x 1¼" x ⅞".

This Little Switch Saves Money

Costs less—permits simplification of your designs. Spindle extensible through base to permit ganging of mechanical and electrical controls . . . spade terminals for quick wiring . . . dummy terminals, if required, to eliminate need for blocks.

This Little Switch Is The NEW "Diamond H" Series 390 Rotary

. . . single or double pole, two to twelve positions with stop as required. Single, two-hole or special mounting arrangements. Completely interchangeable with the widely used "Diamond H" Series 240 switches which are still available.

Write today for complete information to meet your requirements

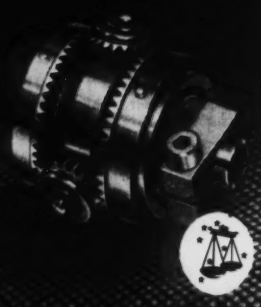
THE HART MANUFACTURING COMPANY

118 BARTHOLOMEW AVE., HARTFORD, CONN.

—ITEM 642—

HOLLOW SHAFT DIFFERENTIAL

HIGH ACCURACY IN MEASURING COMPUTER ANGULAR POSITIONS OR VELOCITY SUMS



This Librascope precision computer component has only 10 min. backlash. Hollow shaft eliminates stocking custom shaft lengths in breadboard work and cost reduction in production assembly operations. Small size, low inertia, precision ball bearings, 3 point contact with spider gears. Can be installed or removed without disassembly of differential or instrument. *Write for catalog information.*

SPECIFICATIONS:

Inertia: .074 oz.-in.
Max. Backlash: 10 min.
Axial length: 1-3/16"
Clearance radius: .545"
3/16" dia. shaft
Weight: 1¼ oz.

Computers and Controls

LIBRASCOPE

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

LIBRASCOPE, INCORPORATED

1607 FLOWER ST., GLENDALE, CALIF.

—ITEM 643—

New Parts

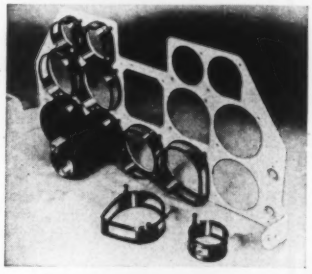
a collet fitting that is easily assembled or disassembled at the point of installation. **Marlin Mfg. Corp.**, 12410 Triskett Rd., Cleveland 11, O.

—Circle ITEM 487

Instrument Clamps

are lightweight, nonmagnetic

Designed to permit installation and removal of an instrument from



the front of the panel, these AN-approved aircraft instrument mount clamps are available in 1½, 2 and 3¼ in. sizes. The expanded mount clamp is attached to the rear of the instrument panel by two screws. Cam action on a master screw tightens the clamp around the instrument, securely locking it in place. Nonmagnetic, the clamps are 60 per cent lighter than standard designs. **Aeroquip Corp.**, 303 South East Ave., Jackson, Mich.

—Circle ITEM 488

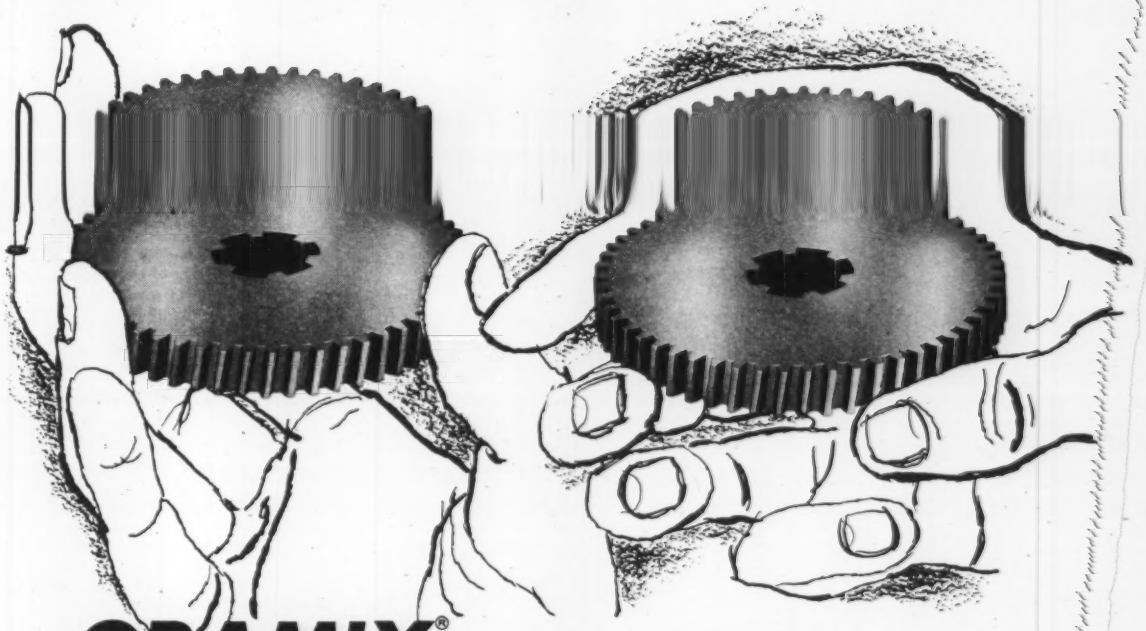
Fractional-HP Motors

for pad, ring or end mounting

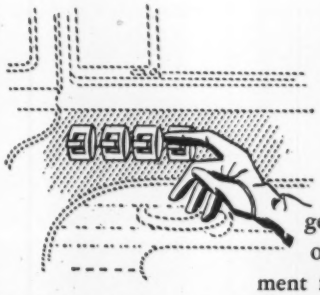
Model 9200 fractional-horsepower induction motors, with sleeve bearings and ventilated frames, can be supplied for pad mounting, resilient-ring mounting or end mounting. Ratings for permanent split-capacitor, single-phase motors (50, 60, 120 cycle) are: 2, 4 or 6-pole induction—1/150 to 1/50 hp; 2, 4 or 6-pole synchronous—1/250 to 1/60 hp. Ratings for polyphase motors (50, 60, 120 cycle) are: 2 or 4-pole induction—1/50 to 1/60 hp; 2 or 4-pole synchronous—1/250 to 1/80 hp. **Howard Industries Inc.**, 1760 State St., Racine, Wis.

—Circle ITEM 489

which helical gear costs 80% less?



the GRAMIX® sintered metal helical gear performs better than a forged and hobbed aluminum part for just 1/5 the cost!



By replacing forged aluminum gears with sintered steel GRAMIX helical gears, a manufacturer of automotive equipment found that he could realize an 80% saving and get greater dependability. The gear is a component of an automatic window raising and lowering mechanism currently being used by four different automobile manufacturers. The helical teeth are formed in the compacting dies, and, after sintering, the GRAMIX gear is ready for assembly into the power window unit . . . there is no need for costly machining or time-consuming finishing operations like the hobbed aluminum gear used previously. In spite of the astonishing savings, these GRAMIX gears have proven to be even better than the former forged gear from a standpoint of toughness and wearability.

GRAMIX metallurgists can provide the exact alloy for your design specifications. GRAMIX parts may be oil-impregnated for self-lubrication. They seldom need machining, and will often outlast similar machined parts. Complex shapes can be produced to tolerances as close as .0005". Whatever your requirements may be, it will pay you to investigate GRAMIX.

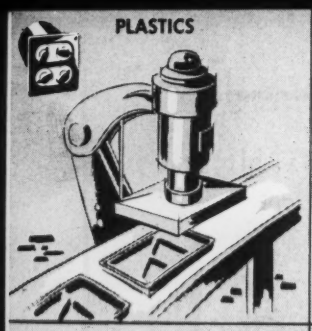
Do you have our big detailed GRAMIX catalog? . . . write today for your copy.

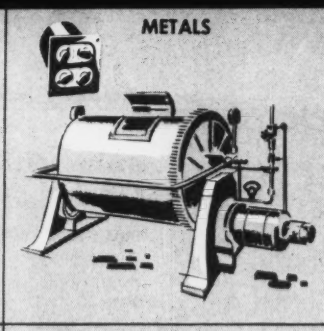
114

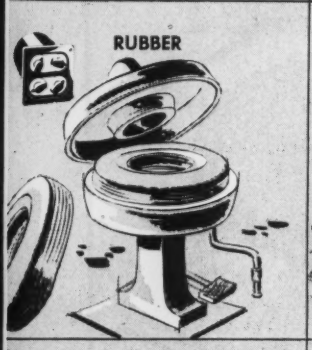
THE UNITED STATES GRAPHITE COMPANY

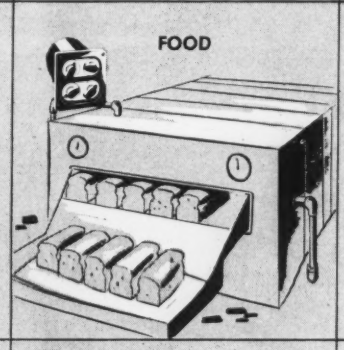
DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

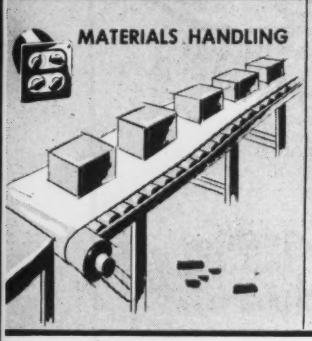
—ITEM 644—

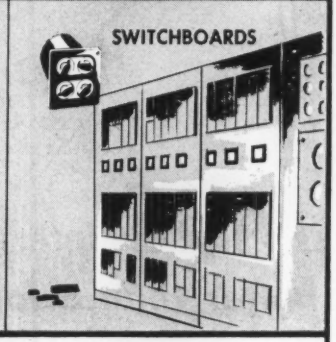












In All These Applications . . .

3 NEW FEATURES OF G-E INTERVAL TIMER IMPROVE CONTROL AND CUT TIMING COSTS

To give you even greater versatility in time control, the General Electric TSA-18 interval timer may now be equipped with these optional features: new reset contacts, elapsed time indication and a program retaining mechanism.

NEW RESET CONTACTS make possible *either* automatic resetting or automatic recycling in the same timer. A simple change in external wiring is all that is necessary to change from one to the other. With ***automatic resetting*** you can eliminate manual resetting or mortgaging another circuit to achieve the reset action. With ***automatic recycling,*** the timer will reset at the end of a time cycle and immediately start the next cycle. This gives you a continuous repeating time-cycle program.

ELAPSED-TIME INDICATION, shown by a small dial on the timer face, gives you a continuous, accurate reading of time elapsed from the start of your time-cycle program—especially useful on long programs.

PROGRAM RETAINING: In case of power failure the program-retaining mechanism will hold the timer at the point of interruption and restart it at this point when power is restored. (Cannot be used in the same timer with reset contacts.)

MANY STANDARD "EXTRAS" are included in the TSA-18 timer: delayed on-and-off timing in intervals from 1 second to 30 hours; knob-locking device to prevent missetting; high setting accuracy of 1%; high repeat accuracy of ¼%; dust-proof case—***all standard at no extra cost.***

YOUR COSTS ARE REDUCED because the TSA-18 interval timer will increase the equipment operators can handle and free them for more productive activity. Waste or spoilage of materials can also be reduced, with the higher degree of uniformity that G-E timed control gives you.

For further information, contact your nearest General Electric Apparatus Sales Office, or write for bulletin GEC-1223 to Section 584-3, General Electric Company, Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

G-E TSA-18 TIMER WILL REDUCE COSTS IN ALL THESE OPERATIONS

IN PLASTICS

Automatic molding
Scheduled mixing of materials
Batch weighing

IN METALS

Heat treating
Flame hardening
Induction heater annealing
Quenching cycles
Firing of regenerative furnaces
Plating
Bath and soak cycles
Motor reversing cycles—tumbling
Batch weighing
Sequencial adding of materials

IN FOOD PROCESSING

Sugar centrifuge control
Dough mixing
Dehydration equipment
Automatic chicken pickers
Roasting processes
Motor reversing cycles—agitators
Adding ingredients in sequence
Infra-red oven control
Molding and pressing
Batch weighing
Bag folders
Heat sealers—plastic bags
Bag and box fillers

IN MACHINE TOOLS

Flame hardening
Heat treating
Resurfacing of grinding wheels
Final polishing intervals
Periodic lubrication

IN RUBBER

Tire and tube curing cycles
Injection period control

IN CHEMICALS

Motor reversing cycles—agitators
Atomic radiation control—setting exposure reading interval
Batch weighing
Sequencial adding of materials
Testing photographic emulsions
Infra-red oven control
Purging of filtration tanks
Dehydration equipment

IN CONTROL PANELS

Single time-interval operation
Multiple time-interval operation
Recycling of timed operations
Sequencial cycling of automatic machines
Motor-reversing cycles
Reclosing of circuit breakers
Unattended substation starting

AND MANY OTHERS

Transit-system scheduling
Glass polishing cycles
Spin and surge protection of deep well pumps
Automatic paint spraying devices
Photo copying equipment
Automatic door closing
Dry cleaning and laundry machines
Alarm initiation
Dust collectors and shakers
Quality control
Materials handling
Periodic test sampling

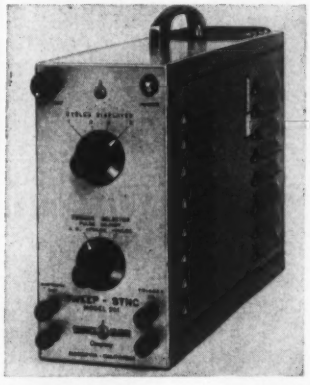
ENGINEERING DEPARTMENT

EQUIPMENT

Sweep Generator

eliminates manual sweep adjustments

This automatic sweep generator, called Sweep-Sync, is for connection to the external-sweep input on the user's oscilloscope. Input trigger signals of any wave shape



(5 cps to 10 kc) are converted by the device to 10-v saw-tooth output signals. The unit produces a linear horizontal triggered sweep on the oscilloscope for displaying a selected number of vertical-axis signal cycles. Once the sweep rate is set, it remains constant. Applications include monitoring vibration waveshapes, circuit development and production testing. **Chadwick-Helmuth Co.**, 472 E. Duarte Rd., Monrovia, Calif.

—Circle ITEM 490

Microfilm Printer

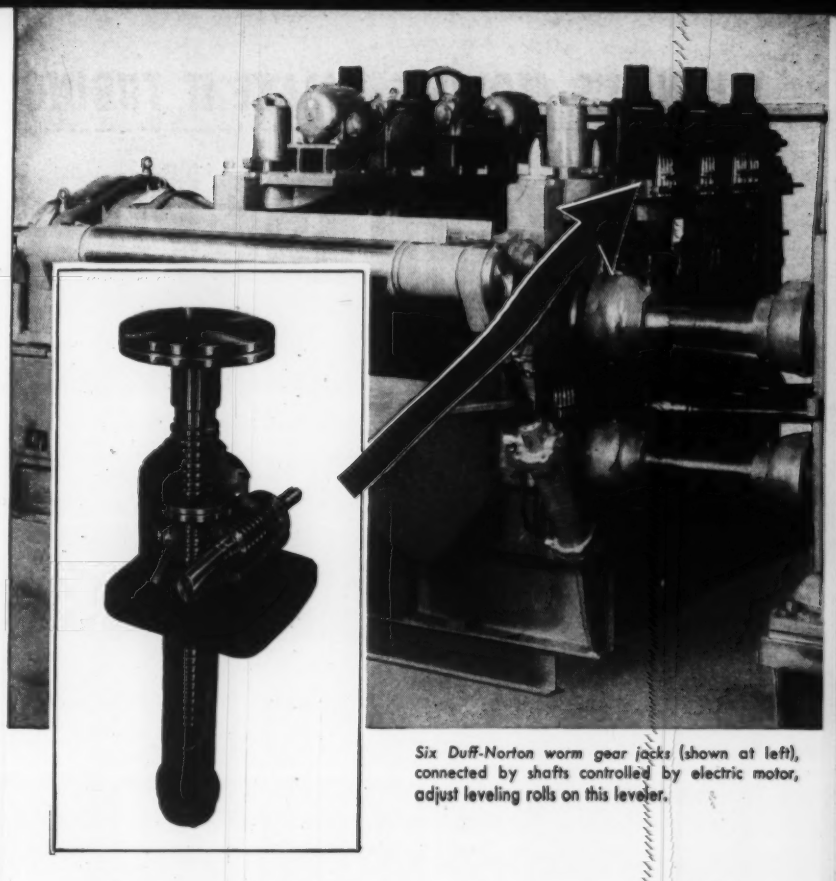
makes ozalid prints at 40 per min rate

Ozacard printer, handling microfilm aperture cards up to 9 in. wide, duplicates microfilm frames on premounted ozalid film cards at a rate of 35 to 40 per min. It operates at speeds ranging from 1 to 10 ft per min, with 1½ to 2 ft per min recommended for most

(*Continued on Page* 228)

←Facing Page—ITEM 645

ITEM 646→



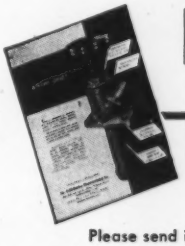
Six Duff-Norton worm gear jacks (shown at left), connected by shafts controlled by electric motor, adjust leveling rolls on this leveler.

Here's a device every machinery designer should know about

It's the Duff-Norton worm gear jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion; applying pressure; resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes to give a positive drive, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 50 tons with any raise up to 25 inches; worm gear ratios, 8:1 to 45:1; turn of worm for each 1 inch raise, 10 to 180; available in either Acme or square threads. For protection against foreign matter certain models of these jacks can be furnished with bellows boots.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting — raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses —adjusting electrodes — overhead crane servicing.

Duff-Norton worm gear jacks are made in 6 standard sizes. Write for booklet!



Duff-Norton Company

DUFF-NORTON COMPANY
Department MD
P. O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your new Worm Gear Jack Brochure.

NAME _____ TITLE _____

COMPANY _____ PHONE _____

ADDRESS _____

WHEN IT'S *MOVING*...MAKE IT *TUBING*

Pound for Pound, Tubular

Wheeled chairs get stiff workouts in fast-moving paraplegic basketball. Tubular construction keeps them strong, safe, maneuverable. When it's moving, make it steel tubing.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Construction is STRONGEST!

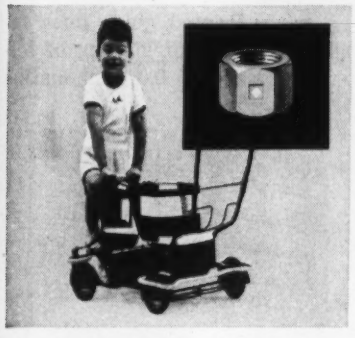
At any given weight, tubing is strongest of all mechanical shapes . . . stronger under compressive load . . . stronger as a beam . . . stronger in torsion.

And, dollar for dollar Republic ELECTRUNITE Steel Mechanical Tubing is your best buy. ELECTRUNITE is the original electric resistance welded tube. It's the quality tube of industry, available in a wide variety of forms, sizes and gages . . . in both carbon and stainless steel.

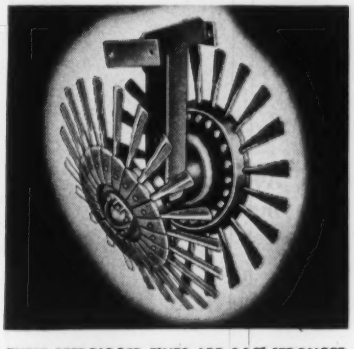
For volume production, ELECTRUNITE tubing is consistently uniform, foot to foot, shipment to shipment. It offers uniform wall thickness and concentricity. Surfaces are free from scratches and pit marks. It offers uniform response to heat treatment. It is easy to fabricate . . . often eliminates some costly fabricating or machining operations.

When your product must be strong, safe, lightweight, investigate Republic ELECTRUNITE Steel Tubing. Republic engineers can help you design it into your products and processes, economically and profitably. Send coupon for facts.

MORE REPUBLIC PRODUCTS MADE FOR MOVEMENT:



"I PUT REPUBLIC NYLOK NUTS TO THE TEST every time I ride my Taylor Tot," reports this young test driver. In spite of all the bumps, bounces and jolts, Nylok Nuts always hold tight. The reason: a special Nylon plug that assures positive locking in any position wherever you stop wrenching. Send coupon for details.



THESE BEET DIGGER TINES ARE 24% STRONGER since John Deere switched to alloy steel. Originally fabricated from carbon steel, they would sometimes break under stress. By taking advantage of alloy's hardenability—plus superior strength—bending and abrasion problems have been eliminated. Send coupon for complete data on Republic Alloy Steels.

DOUGLAS AIRCRAFT ADDED A PASSENGER—AT NO INCREASE IN WEIGHT on their new DC-7 superliner. How? By substituting Titanium for other metals normally used in nacelle construction. Republic is an old hand at this high strength-to-weight business. Send coupon for information on how Republic Titanium and Titanium Alloys may help your product.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
Dept. C-1249
3130 East 45th Street
Cleveland 27, Ohio

Please send me more information on:
☐ ELECTRUNITE® Mechanical Tubing ☐ Alloy Steels
☐ NYLOK* Nuts ☐ Titanium
*U. S. Pat. No. 2,450,694 and pending applications.

Name_____ Title_____

Company_____

Address_____

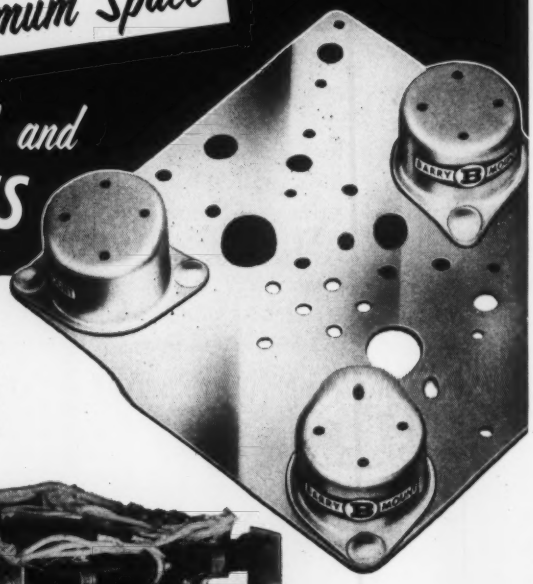
City_____ Zone____ State_____

—ITEM 647—

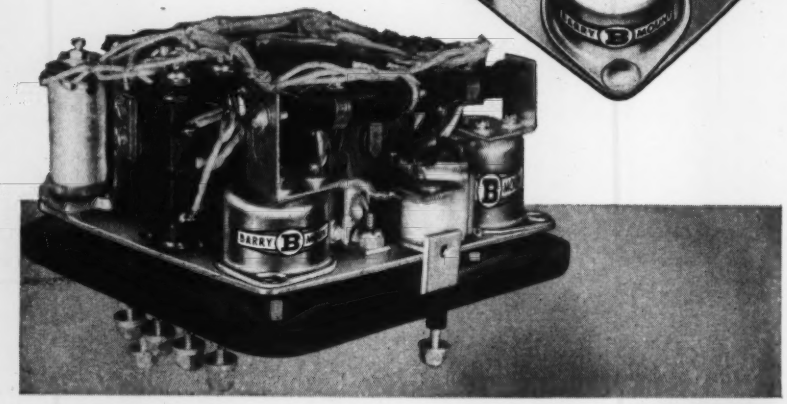
Here's ALL-ANGL Reliability

in Minimum Space

for JETS and MISSILES



ALL-ANGL Mounts integral with base of relay interlock assembly built by Diaphlex Division of Cook Electric Company for F 86 and F 100.



***The attitude gyro* of North American Aviation's F-100 Super Sabre *must* give reliable indication through every flight attitude — or the pilot won't know which way is up.**

That's why ALL-ANGL Barry Mounts are chosen to protect the delicate sensing relays in the interlock assembly for this vital instrument. Close-tolerance operation in all attitudes demands the certain isolation of vibration — assured by ALL-ANGL Barry Mounts.

Two added advantages result:

1. Size of the unit is cut 40% by integrating ALL-ANGL mounts, upside down, in the base plate.

2. Short leads replace long cables because the Barry Mounts float the assembly within its case.

F-100 Super Sabre photo courtesy of North American Aviation, Inc.

When your problem is protection through all flight attitudes, your answer is ALL-ANGL Barry Mounts. Write for data sheets giving detailed information. For recommendations on specific problems, call your nearest Barry Sales Representative.

Barry's Western Division, in Burbank, California, will offer engineering facilities, prototype service, and short-run production of "specials".

BARRY CONTROLS
INCORPORATED

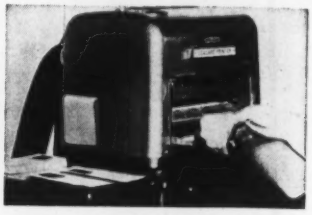
BARRY B MOUNT
SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

722 PLEASANT STREET, WATERTOWN 72, MASSACHUSETTS

—ITEM 648—

Engineering Equipment

(Continued from Page 225)



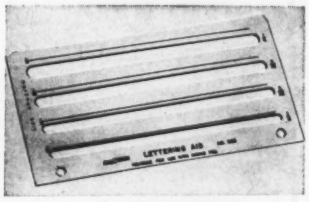
processing. Weighing 60 lb and measuring 16 × 12 × 13 in., the printer makes positive copies from positive microfilm, negative from negative. Electrical requirements are 110 to 120 v, 10 amp, 60 cycles. **Dexter Folder Co.,** Filmsort Div., 50 S. Pearl St., Pearl River, N. Y.

—Circle ITEM 491

Lettering Guide

simplifies hand lettering

Neatness of hand lettering is improved by this No. 925 lettering aid template, which has slot sizes from 1/8 to 1/4-in. Because the slots are beveled, the template may be reversed and used with an inking pen. Printed guide lines facilitate equidistant spacing of lettering. Made of 0.040-in. mathematical quality plastic, the template measures 6⅞ by 3⅜ in. **Rapidesign Inc.,** Box 592, Glendale, Calif.



—Circle ITEM 492

Reference Junction

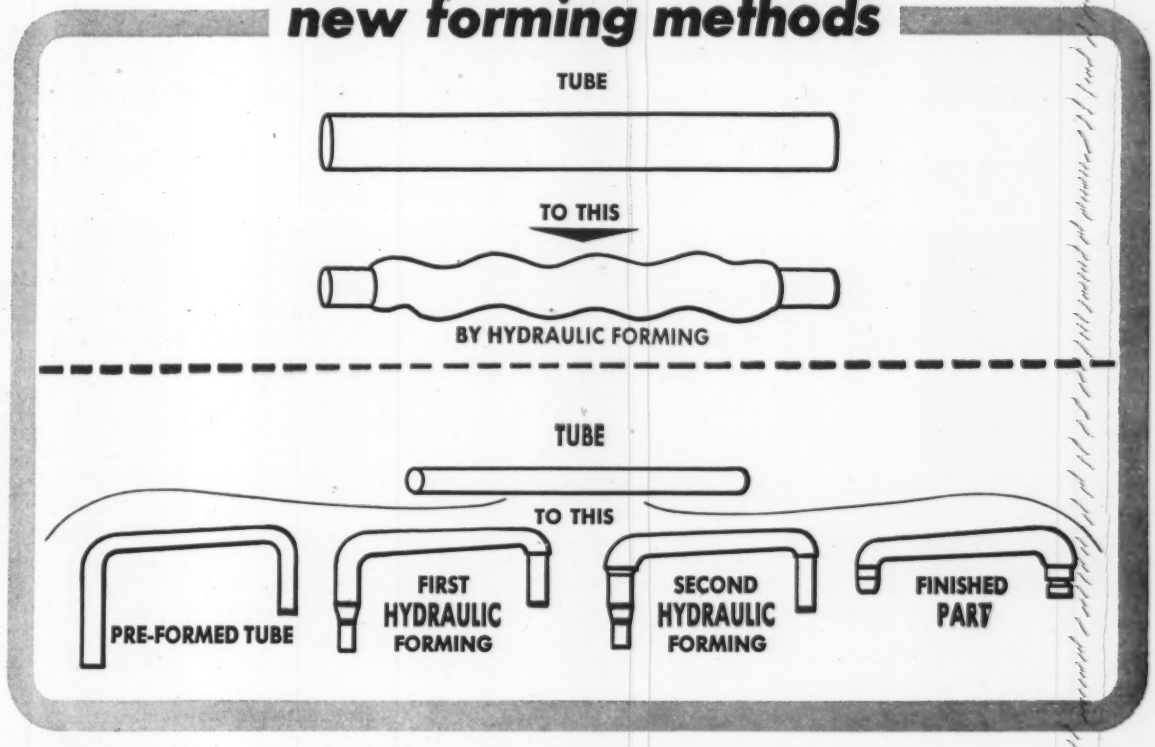
provides constant-temperature cold-junction for thermocouples

Developed for use with multichannel temperature measuring systems, model RJ-1 thermocouple reference junction provides a thermostatically controlled temperature reference for up to 24 thermocouple circuits. Choice of iron - constantan, chromel - alumel, or chromel-constantan is available in each of 12 independent circuits. At a reference temperature of

For More Information Circle Item Number on Yellow Card—page 19

IF YOU PRODUCE PARTS FROM STEEL TUBING...

it may pay you to investigate new forming methods



Often a single change made in your production procedures can result in a better product with savings in fabricating time and cost. And even if your current production methods are "good enough", you can't afford to overlook any improvement which might be adapted to your operation. For example, hydraulic forming is a unique, simple forming method having advantages—where applicable—which include fewer operations to produce the finished part, reduced tool costs and lower maintenance costs.

But whether you form your product hydraulically or by other methods, the original tubing you choose must be *right* . . . must have the precise combination of formability and strength required for your product. Only with the *right* tubing can you make that product to quality standards, at the lowest possible cost to yourself. And whatever your manufacturing requirements may be, B&W Mechanical Tubing can meet them. It is available in the fullest range of analyses, sizes, finishes and properties, and *one* combination of these is tubing tailor-made to your requirements.

Call for Mr. Tubes. He's your link to B&W through our Regional Sales Offices and a nationwide network of experienced tubing distributors. Get the benefit of his complete knowledge of tubing for all applications to help you match tubing to your requirements and to point out practical fabricating economies.

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa.— Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

B&W SEAMLESS and WELDED TUBES

TA 4053(M)

The Good in our slogan

F. G. Sorensen

CHAIRMAN, THE CINCINNATI GEAR CO.

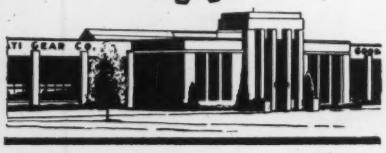
Our slogan, "Gears . . . Good Gears Only," seems almost unpretentious by modern standards. In this day of soaring advertising superlatives and grandiose claims of product superiority, we feel it sounds a little old-fashioned—and that's just the way we want it.

There is little about our production today, from a technological stand-point, that resembles our operations of even a few decades ago. New modern machinery in an ultra-modern plant has enabled us to offer a degree of precision and efficiency undreamed-of in our fathers' time. But, while we've striven to be second to none in utilizing the advancements made possible through technological progress, we've also attempted to retain something of the old-fashioned craftsmanship and pride of workmanship that is all too often lost in the modern shuffle of mass production.

We specialize in just one thing: the manufacture of the best custom gears that can be produced. To our modern production techniques we add this old-fashioned ingredient of craftsmanship; the result is just what is promised in our simple slogan: we produce *good* gears, and good gears *only*. This simple claim is backed by our reputation — we *deliver* good gears only. It's a claim and a reputation we intend to perpetuate for many years to come.

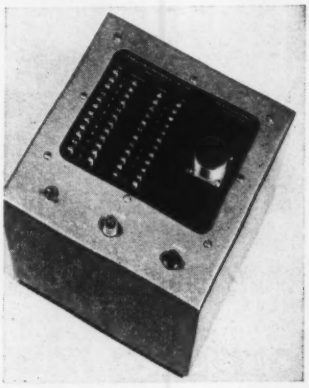
THE CINCINNATI GEAR CO.
CINCINNATI 27, OHIO
"Gears—Good Gears Only"

CINTI



—ITEM 650—

Engineering Equipment



150 F, for which thermocouple tables are available, rated accuracy is ½ F under normal ambient conditions. Similar models are offered with a variety of arrangements in input and output coupling, thermocouple types and number of circuits. **Pace Engineering Co.**, 6914 Beck Ave., North Hollywood, Calif.

—Circle ITEM 493

Mathematical Charts

give quick solutions to common calculations

Calculine mathematical charts give quick graphical solutions to mathematical operations such as multiplication, division, squares, cube roots, etc. The charts consist of a log scale superimposed diagonally on a log-log grid. Margins are divided into major graduations from zero to ten with line subdivisions to permit accurate reading. To obtain a solution, the user locates the intersection of the horizontal and vertical lines representing the numbers involved, then reads the solution on the diagonal line at the point of intersection. Charts are three-hole punched for use in data books, and are especially convenient for use in labs and drafting rooms. **Frederick Post Co.**, 3650 N. Avondale Ave., Chicago 18, Ill.

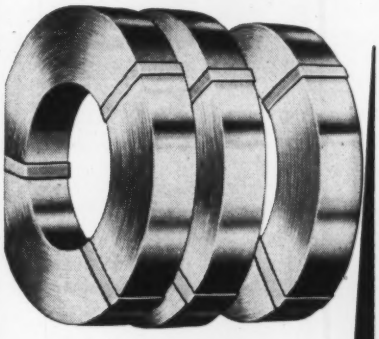
—Circle ITEM 494

Digital Ratiometer

gives voltage ratios at 60 channel per sec rate

Model 330 digital ratiometer provides a discrete four-digit indication of the ratio between two voltages or resistances stable to 0.01

Alloy Strip in Precision Sizes meets New Design Needs...



From 0.0005 in. to 0.040 in. thick and 0.090 to 6 in. wide, these alloys are available as special-tolerance strip:

Beryllium Copper
Phosphor Bronze
Nickel Silver
Brass
Chromium Copper
Stainless 17-7PH
Invar
Magnetic: High Nickel

Some immediately available. Others rolled to order in 2 to 21 days. Can be supplied in coils or straight lengths with slit or filed edges—also cadmium plated.

Write for Bulletin 7 TODAY.

PENN
PRECISION PRODUCTS, INC.
501 Crescent Avenue • Reading, Pa.

SALES OFFICES

New York
H. G. WILLIAMS
Ramsey, N. J.

Philadelphia
J. A. RHODES
Upper Darby, Pa.

Boston
F. G. STROKE

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RANDOLPH SALES CO.

Chicago
R. A. BURKETT

Los Angeles
KRUSEN WIRE & STEEL CO.

WAREHOUSES

New York
BERYLLIUM COPPER SUPPLY CO.
Little Falls, New Jersey

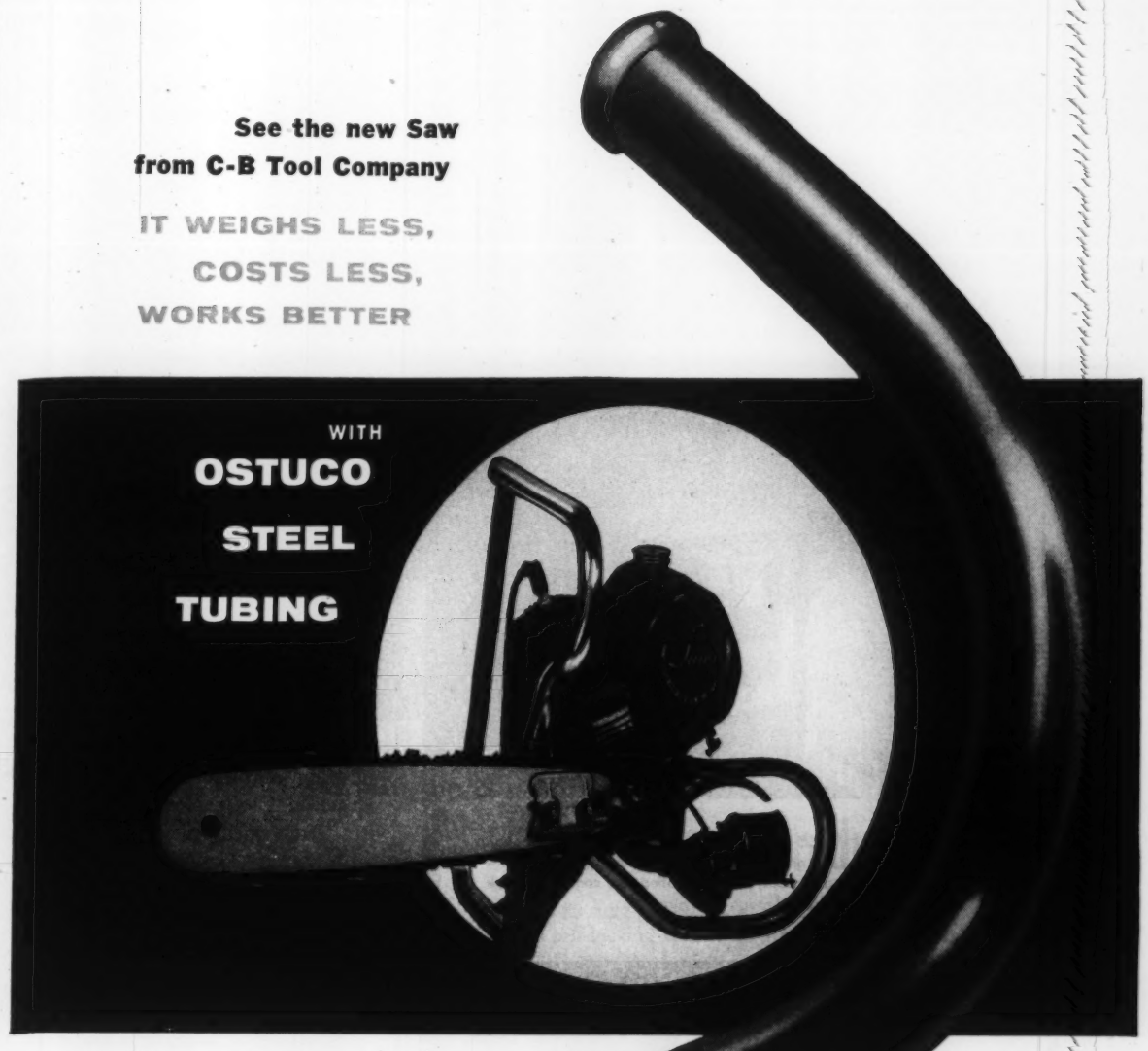
Chicago
PRECISION STEEL WAREHOUSE INC.

Los Angeles
KRUSEN WIRE & STEEL CO.

—ITEM 651—

See the new Saw from C-B Tool Company

IT WEIGHS LESS,
COSTS LESS,
WORKS BETTER



The C-B Tool Co. Story

It was easy! Engineers from C-B Tool Company, Lancaster, Pa. and OSTUCO in Shelby worked out a welded steel tubing component to replace a heavy, bulky oil reservoir and to serve as a handle for the new saw. See the difference this makes in the new Lancaster Model 400A chain saw:

- **Saves Cost—$4.25 on each chain saw!**
- **Saves Weight—3 pounds on each unit!**
- **Works better—Saw now has positive, continuous oiling instead of push-button oiling by the operator.**

Perhaps this story from C-B Tool has a message for you.

If you have trouble with see-sawing production costs and quality, OSTUCO may have the answer to your problems. Unique single-source service eliminates interplant shipment, reduces error, gives better production control. See about it . . . see OSTUCO! Contact the Shelby office or your nearby OSTUCO Sales Engineer for details.

OSTUCO SHELBY, OHIO **OSTUCO TUBING**

SEAMLESS AND ELECTRIC WELDED STEEL TUBING
—Fabricating and Forging

OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company • ***SHELBY, OHIO***
Birthplace of the Seamless Steel Tube Industry in America

SALES OFFICES: *BIRMINGHAM • CHARLOTTE • CHICAGO (Oak Park) CLEVELAND • DAYTON • DENVER • DETROIT (Ferndale) HOUSTON • LOS ANGELES (Beverly Hills) • MOLINE NEW YORK • NORTH KANSAS CITY • PHILADELPHIA PITTSBURGH • RICHMOND • ROCHESTER • ST. LOUIS ST. PAUL • SALT LAKE CITY • SEATTLE • TULSA • WICHITA*

CANADA, *RAILWAY & POWER ENGR. CORP., LTD.*
EXPORT: *COPPERWELD STEEL INTERNATIONAL COMPANY 225 Broadway, New York 7, New York*

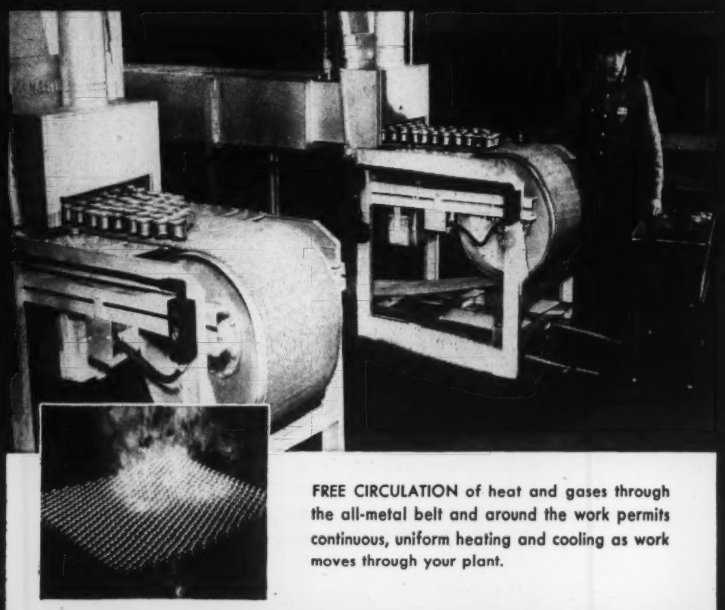
—ITEM 652—
For More Information Circle Item Number on Yellow Card—page 19

Cambridge

WOVEN WIRE CONVEYOR BELTS

take the "hot spots" out of

ANNEALING & BRAZING



FREE CIRCULATION of heat and gases through the all-metal belt and around the work permits continuous, uniform heating and cooling as work moves through your plant.

By combining controlled movement with free circulation of process atmospheres, Cambridge Woven Wire Conveyor Belts eliminate batch annealing and brazing. There is no formation of "hot spots" which produce local stresses. Continuous, belt-to-belt flow through subsequent quenching and washing operations as well as heating, cuts costs and provides fast, uniform production.

REGARDLESS OF YOUR INDUSTRY...

... metalworking, food, chemical, glass and ceramic ... whether the machines are for your own operation or resale, you'll find "free circulation" only one property of Cambridge belts that makes combined movement and processing practical and economical. Open mesh construction also provides rapid drainage of process solutions. Belts are corrosion resistant and impervious to heat damage, even at 2100°F. They have no seams, lacers or fasteners to wear more rapidly than the body of the belt. Cambridge Woven Wire Belts are made in any size, mesh or weave; from any metal or alloy. Special surface attachments are available to hold products during inclined movement.

Call in your Cambridge FIELD ENGINEER to discuss how you can cut costs by continuous operation. Look under "BELTING, MECHANICAL" in your classified phone book. OR, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

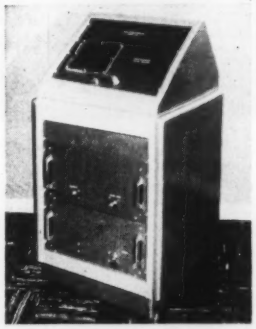
The Cambridge Wire Cloth Co.

WIRE CLOTH · METAL CONVEYOR BELTS · SPECIAL METAL FABRICATIONS

Department N, Cambridge 6, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Engineering Equipment



per cent. Ratiometer indications are independent of reference excitation accuracy. Readings take less than 10 millisec, and up to 60 channels may be scanned per second. In addition to visual display, provisions are included for digital readout to printers or card and tape punches. Application is found in many automatic control situations, such as those requiring digital indication of mechanical position or process-data logging. **Franklin Electronics Inc.**, E. 4th St., Bridgeport, Pa.

—Circle ITEM 495

Power Supply Converter

gives 26-v dc output on 200-v, 400 cycle input

Designed to permit operation of dc-type oscillographs and similar instrumentation in airplanes equipped with three-phase ac systems, type 3-134 power supply has a continuous-duty rating of 13 amp. Rating at 25-per cent duty cycle is 20 amp for five minutes. Output is regulated within 23.5 to 28.5-v dc range for inputs ranging from 190 to 210 v, frequencies from 380 to 420 cps, and loads from 3 to 20 amp. Measuring 4.5 x 5 x 7.5 in., the unit weighs 13 lb and is suitable for operation at ambient temperatures from −65 to 150 F and pressure altitudes to 50,000 ft. **Consolidated Electrodynamics Corp.**, 300 N. Sierra Madre Villa, Pasedena, Calif.

—Circle ITEM 496

The Falk Corp., of Milwaukee, also uses Elastic Stop nuts in the tie rod assembly . . . and on the gear housing to maintain tight cover fit.

Elastic Stop® nuts solve critical gear adjustment problem in new speed-reducing unit!

In its rugged new Shaft-Mounted Drive, The Falk Corporation uses a self-locking Elastic Stop nut to secure the high-speed gear to the intermediate shaft, as shown in the illustration on the left.

The precision-made Elastic Stop nut stays firmly in place and the close seat-squareness tolerances maintain the exact original gear adjustment withstanding severe vibration caused by shock loads transmitted through the gears. Costs are cut because drilled bolt holes and cotter pins are eliminated.

Here's how this Elastic Stop nut works: The familiar red collar of the Elastic Stop nut is deliberately undersized in relation to the shaft (or bolt) diameter. It grips the shaft with a perfect fit, enforces a continuing self-locking pressure against the metal threads, and holds the nut securely in place at the desired point on the shaft. This same tight-fitting locking collar also provides a seal that prevents oil from seeping along the bolt threads, wherever oil seepage is a problem. And because the bolt threads are protected against moisture from without, the nuts cannot become "frozen" to the bolt by corrosion. The elastic recovery of the red collar permits extended re-use of Elastic Stop nuts.

Mail the coupon for information on how Elastic Stop nuts can solve your specific fastening problem.

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA® TRADEMARK

ROLLPIN TRADEMARK

Elastic Stop Nut Corporation of America
Dept. N67-64, 2330 Vauxhall Road, Union, N. J.
Please send the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

City_____ Zone____ State____

—ITEM 654—

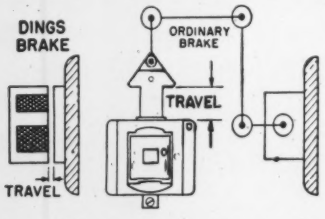
DINGS BRAKE BRIEFS

THRU-SHAFT DESIGN SOLVES INSTALLATION PROBLEMS

Simple modification of the cover converts Dings Magnetic Disc Brakes for thru-shaft installation. This facilitates direct coupling or the use of hand cranks, electrical tachometers, pulleys, plugging switches, etc. Dings Brakes accommodate standard NEMA shaft extensions, and are designed to meet new re-rated and old NEMA motor standards. They easily mount on all NEMA "C" flange motors and are interchangeable with any "C" flange mounting disc brake.

FULL DIRECT ACTION

Direct acting magnets eliminate all mechanical linkages and levers. Movement of the braking assembly is measured in thousandths of an inch,



assuring instantaneous release and consistent, positive stops. All wear is confined to the friction linings.

ADDITIONAL ADVANTAGES

Dings Magnetic Disc Brakes offer a combination of outstanding features for any industry which requires automatic, controlled, *all-ways* dependable braking.

1. Wide torque range—1½ to 175 lbs. ft.—easy torque adjustment.
2. Fail-safe design in event of power failure.
3. Simple design and rugged, compact construction.
4. Standard drip-proof or dust-tight waterproof enclosures.
5. Floor or motor mounting, horizontal or vertical operation.

Specify Dings Magnetic Brakes from your regular motor supplier. While these units are easy to select and apply, it will pay you to take advantage of Dings complete engineering service to help solve specific brake problems. Write for Bulletin BK4003.

DINGS BRAKES, INC.
A SUBSIDIARY OF DINGS MAGNETIC SEPARATOR CO.
4714 West Electric Avenue
Milwaukee 46, Wisconsin

See our catalog in SWEETS PRODUCT DESIGN FILE
Section 5a/Di

DB256½

—ITEM 655—

Stress Relief

OUR frequent guest in this column, J. P. Henderson, shows up this time with a proposal which, in effect, is that others should practice what he preaches and practices:

"Be Sure and Write!"

Have you ever thought about writing an occasional article, or even more regularly, a number of them as a sideline? There is only one really important requirement, namely, that you have something to say. Occasionally one reads stuff in print that makes one doubt if even that requirement has been met. But, by and large, it's a worthwhile idea—for you and your potential readers.

Perhaps you have some opinions on the current technical scene, or you've developed information on how to handle a certain problem, or . . . the list is endless.

Why not write it up and submit it as a proposed article?

An engineer might be concerned with two kinds of writing effort. The first is the "professional" paper, submitted to a technical organization for presentation at a meeting, and ultimately published in the archives. Originality, format, and a number of other hurdles are important in such a case, and it is usually wise to obtain a "writer's guide" from the organization to which such a paper is submitted.

Articles are the second kind of writing effort. But writing for technical magazines or so-called trade journals is a lot less restrictive. Complete originality is not always necessary if you give old information a fresh look or a new twist. The format is not so restrictive. Typed, double-spaced manuscript with photographs, (glossy) or reasonably clear sketches which will ultimately make cuts for illustrations—all of this makes a package that will usually get the careful attention of an editor.

Why People Want To Write:

There are a limited number of mo-

Endurance Rated
COUNTERS
to Fit every need

200 MILLION COUNT LIFE

PIC
Silver King Stroke Counters

Unequalled for Automobile and Aircraft factories; stamping, metal working, die casting and plastic molding machines; laundry, printing and all kinds of equipment.

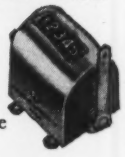
6 MILLION COUNT LIFE

PIC
Junior King

The proven answer for office machines, amusement machines, and factory equipment where service is moderate.

3 MILLION COUNT LIFE

PIC
SMX Tamperproof



Millions used for vending machines and other equipment where space is limited.

200 MILLION COUNT LIFE

PIC
Silver King Revolution Counter

For measuring machines, metering equipment, etc. Available with flexible shaft for convenient location.

1 BILLION COUNT LIFE
10,000 CPM

PIC
Clipper Coil Winding Counter

Unequalled for high speed coil winding.

See your PIC Representative or write.

PIC
PRODUCTION INSTRUMENT CO.
702-08 W. Jackson Chicago 6, Ill.

—ITEM 656—

$\frac{T^P + F}{H^e} = YS$

use the SYNCHRON* formula to solve your timing problem

The Synchron Formula can help you cut production costs, make designs *work* the way you plan them.

Apply it to your timing problem. Gather the factors . . . T^P, the *Timing Problem,* plus F, the *Facts* (proposed mounting methods and a simple sketch). Send this data to the denominator in our equation . . . H^e, the *Hansen Engineering Department.*

$T^P + F$ divided by H^e equals YS, *Your Solution* to the problem and an answer that will help your design to be more sound, still less expensive to produce.

You'll find the Synchron Formula an easy way to the solution of your timing motor problem. Hansen Engineers are specialists; learn to rely on their 48 yrs. of experience designing, building, testing, and specifying timing motors for every type of application.

Scores of manufacturers look to Synchron Motors and Hansen Engineers to match the timing specs in the development of their designs. This trust is priceless to both Hansen and its customers . . . a pledge of confidence as famous as the Synchron Motor.

Take advantage of the Synchron Formula, by contacting your Synchron Representative, or write direct to Hansen. Your inquiry will be given prompt, confidential attention.

h¹ *"Workhorse of the industry*

*SYNCHRON synchronous motors operate smoothly, evenly in any position; at temperatures from —40° to +140° F.; start instantly under load; pull up to 20 in. oz. at 1 RPM. Available in 42 speeds from 0.8 RPM to 600 RPM.

SYNCHRON

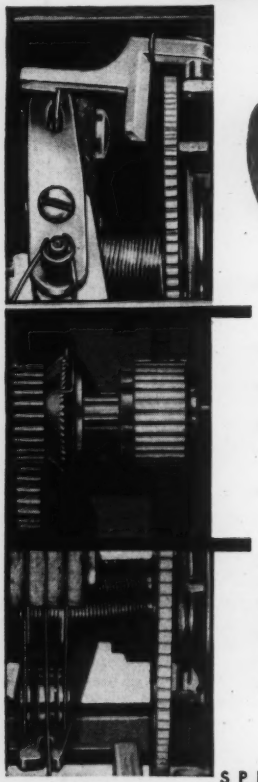
SYNCHRONOUS MOTORS, TIMING MACHINES, CLOCK MOVEMENTS, MAGNA-TORC D.C. MOTORS

HANSEN MANUFACTURING CO., INC. ESTABLISHED 1907 PRINCETON 12, INDIANA

FACTORY REPRESENTATIVES: The Fromm Co., 5254 W. Madison St., Chicago, Ill. • R. H. Winslow Assoc., 123 E. 37th St. New York, N.Y. • Electric Motor Engineering, Inc. 8255 Beverly Blvd., Los Angeles 48, Cal. and 3907 Lyon Ave., Oakland, Cal.

—ITEM 657—

NEW!



CRAMER

automatic reset
INTERVAL TIMER

NEW—Full-vision 300° protected dial for fast, accurate readings.

NEW—Large friction setting knob with integral push button.

NEW—Repeat accuracy within ±½ of 1% of full scale.

NEW—15-amp. open-blade switches, positive quick-make, quick-break operation.

NEW—Multi-position terminal block offers wiring flexibility, side or rear connection.

Powered by the high-torque (30 in. oz. @ 1 r.p.m.) Cramer synchronous motor, the Type 241 Automatic Reset Interval Timer has been designed and tested to new standards for *maintained* accuracy over a long service life. Available in ranges from 15 seconds through 24 hours. Write for complete information.

SPECIALISTS IN TIME CONTROL

CRAMER CONTROLS CORPORATION
Formerly The R. W. Cramer Co., Inc.
BOX 6, CENTERBROOK, CONNECTICUT

Cramer TIMING DEVICES

19CR56

—ITEM 658—
For More Information Circle Item Number on Yellow Card—page 19

tives, although each probably combines to a different extent and in a different way in the individual bosom of the budding writer.

1. *Seeing one's name in print.* This is only a temporary thrill. Every first-time author gets a kick out of it. He shows his brain child proudly to his associates and leaves the journal open on his desk so that his name shows. After he has had two or three articles accepted he becomes a less ardent personal press agent. After a dozen or so, he may honestly overlook telling anyone about his latest *opus*.

2. *Wanting to tell the world.* This is a common motive. You know something and you would like to tell others about it. It could be useful to them and you have a sincere desire to broadcast it. Under this heading also comes gripes. Something in the current scene displeases you, or at least you consider it worth blasting at. Many professional newspaper columnists are apparently so actuated.

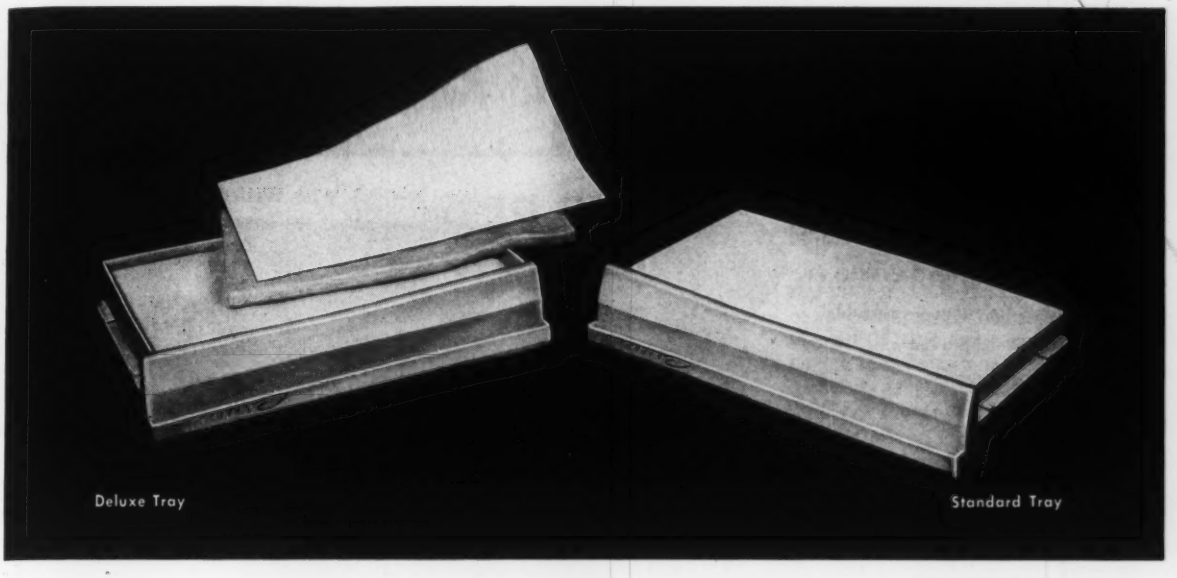
3. *Money.* This is a prime motive for many writers but can hardly be of great importance to the average technical writer. Most magazines pay page rates that can't be compared with the author's pay rate on his full-time job.

All in all the technical writer must be spurred by some motive other than money. If he closes his eyes to it, writing for other reasons, then the check can come as a pleasant surprise. It's like finding it in the street—or receiving an unexpected dividend.

4. *Prestige.* Many a young engineer, looking at his prospects, his ambitions, and at some of his better-known associates, embarks deliberately on a writing campaign to enhance his prestige. Whether this seems to be a noble motive or not, it is real and common enough. And such a plan *can* be a ladder.

Many companies urge their young men to write. But if it is personal advertising, then one had better practice some of the precepts of the advertising profession.

Hit them often! One paper or article, unless it is extremely outstanding, may have little effect. It may take a half-dozen efforts, stretched over a period of years to



NOSCO "CAN DO"

TWO different refrigerator trays from ONE CONVERTIBLE MOLD

One of America's largest refrigerator manufacturers needed two trays with the same over-all dimensions and needed them fast! Their deluxe tray required a pocket to contain an insulation pad; their standard model required no insulation.

Here's where NOSCO "Can Do" came into play. Our engineers devised one *convertible mold,* which, with the addition of inserts, would produce either tray.

Nosco designed this mold so that insert parting lines were attractively blended into the tray design. By efficient high-production molding—a fundamental of NOSCO "Can Do"—we met the delivery requirement, and our customer was saved the cost and time of an expensive extra mold!

Nosco molded the two trays, also spray-decorated and conveyor-assembled them to the customer's complete satisfaction. Just one more happy example of NOSCO "Can Do." Why not let us send the Nosco Sales Engineer near your plant to start NOSCO "Can Do" working on your next plastic part.

NOSCO plastics, inc. • erie 2, pa.

World's largest injection molding plant

For other case histories—and a glimpse of the Nosco plant and facilities, send for the free 12-page brochure.

Nosco Plastics, Inc., Erie 2, Pa. Send_____copies of brochure: "How the Nosco Plant Works to Produce Your Needs in Practical Plastics."

NAME_____ TITLE_____

FIRM_____

ADDRESS_____

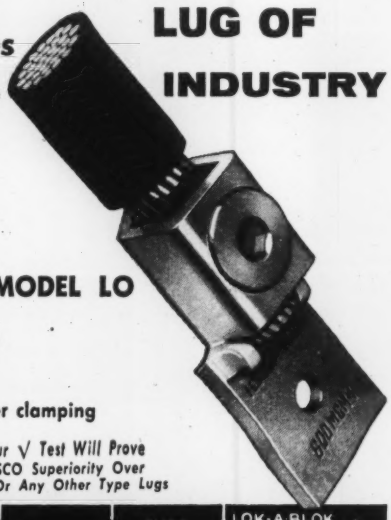
CITY_____ STATE_____

—ITEM 659—

ILSCO THE BIG LUG OF INDUSTRY

For Superior Quality
√ Check these features

- ☐ Pure copper, 100% conductivity
- ☐ Wide wire range—re-usable
- ☐ U/L-CSA Approved
- ☐ Compact—rugged
- ☐ Advanced designing
- ☐ Sound engineering
- ☐ Speedy installation
- ☐ Cool operation—takes overload
- ☐ No special tools needed
- ☐ All screws wax-treated for better clamping



MODEL LO

ALL THESE FEATURES AT LOW COST

Your √ Test Will Prove ILSCO Superiority Over Cast Or Any Other Type Lugs

Write for Catalog #50 and Samples

ILSCO CORPORATION

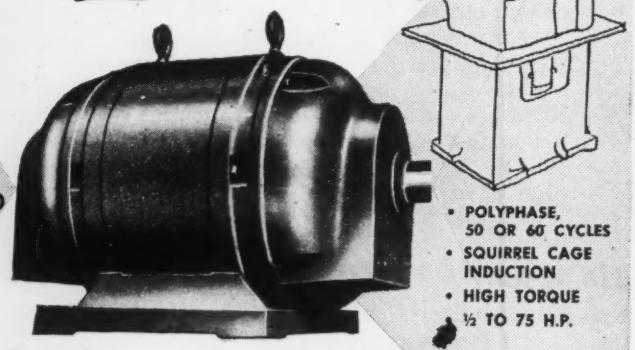
5752 MARIEMONT AVE. CINCINNATI 27, OHIO

—ITEM 660—

VALLEY BALL BEARING MOTORS

Custom Built . . .

NOT Custom Priced!



AIR COOLED

- POLYPHASE, 50 OR 60 CYCLES
- SQUIRREL CAGE INDUCTION
- HIGH TORQUE
- ½ TO 75 H.P.

Cool Running . . . Continuous Service . . .

that's the axiom Valley Motors live up to.

They have been tested and proven in every industry where dependable service and power is a requirement. Remember they are semi-enclosed to assure protection against dripping or splashing liquids, metal chips and abrasive dust.

WRITE FOR COMPLETE INFORMATION

VALLEY
ELECTRIC CORPORATION
4221 Forest Park Blvd. • St Louis 8, Mo.

—ITEM 661—

Stress Relief

make your name recognizable and your reputation mildly enhanced.

Who Writes Most: Bear in mind that we have been considering only technical writing—as a side line. However, some figures about authors in general have been compiled lately and might be worth a quick look.

Consider the magazine racks in the corner drug store, or the ever-filled new book counter. Think of all the fiction and articles it takes to fill all of those magazines every week or every month, or to keep the book presses so busy. One is apt to think of a vast army of writers, making presumably a lush and easy living from their works.

The truth is surprising. Aside from newspaper men and editorial staffs it has been estimated that there are only about 200 people in the United States who make a living from writing alone. All of the rest are part-time authors, working at something usually completely different to keep the wolf from the door.

Out of a study of writers appearing over a year in ten leading magazines, over half were "one-shotters"—persons who had never written before, and quite presumably, never would again. They were in print, often with named or unnamed ghost-writers, because they sailed around the world by themselves, robbed a bank, or happened to work in the movies.

The rest of the material was supplied by part-time authors, staff members, or the few 100 per cent professionals.

So if you have that itch to write, but fear that its mysteries are beyond you—or that it's being done by people of another world—better reconsider. Amateurs and part-time writers are doing most of it in every field.

—J. P. HENDERSON

Well, as editors, we can't help but agree for the most part with J. P.'s ideas on article writing. And his discourse reminds us that several booklets are available from MACHINE DESIGN for the guidance and inspiration of authors. If you'd like to have them, just write to Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

For More Information Circle Item Number on Yellow Card—page 19

look at the EXTRA STRENGTH *in these gears*

Notice how the teeth are continuous across the face of each gear in the photo? That is a characteristic of Farrel herringbone gears, which, instead of a useless center groove, have a *backbone* where the helices meet. This puts the entire face width of the gear to work for you. It pays off in *extra strength* and greater load and shock capacity – in smaller space.

The answer lies in the unique method of manufacture. The machines that cut Farrel gears–famous Farrel-Sykes generators–make continuous tooth herringbone gears. The center groove required for tool clearance by other machines is replaced by useful working tooth area.

Backbone comes in any size up to 23 feet diameter – for virtually any application. Ask for details.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONN.

Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.

Sales Offices: Ansonia, Buffalo, New York, Boston, Akron, Detroit, Chicago, Minneapolis, Fayetteville (N. C.), Los Angeles, Salt Lake City, Tulsa, Houston

FB-1070

This comparison shows the greater tooth area of the Farrel continuous tooth herringbone gear (left) which gives it greater strength than the double helical gear with center groove (right).

Farrel-Birmingham®

—ITEM 662—

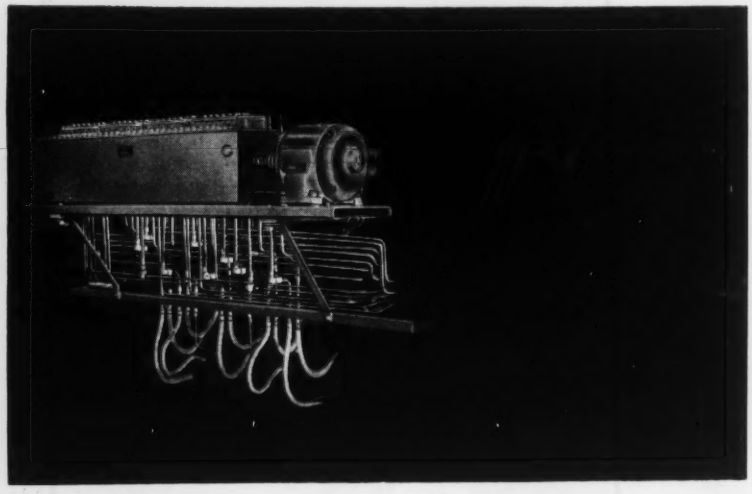
HOW BEST TO LUBRICATE

MANZEL *has the Answer!*

Pressure Application

Exact Amounts

Accurately Timed



★ Manzel has the answer to simple or complex questions of dependable, care-free, automatic lubrication — the answer to putting exactly the right amount of lubricant at the right places and right times — the answer to lubrication against discharge pressures as high as 30,000 P.S.I.G. There is a Manzel Force Feed Lubricator to meet your specifications. And Manzel engineers are specialists at adapting them to your special needs. To answer any lubrication problem, write Manzel.

Manzel

Professionally qualified engineering representatives throughout the country.

DIVISION OF

HOUDAILLE INDUSTRIES INC.

276 BABCOCK ST., BUFFALO 10, N. Y.

—ITEM 663—

For More Information Circle Item Number on Yellow Card—page 19

THE ENGINEER'S Library

Recent Books

Mechanical Engineering Practice, 5th Edition. *By Charles F. Shoop, emeritus professor of mechanical engineering, University of Minnesota, and George L. Tuve, professor of mechanical engineering, Case Institute of Technology;* 471 *pages,* 6 *by* 9 *in., clothbound; published by McGraw-Hill Book Co., Inc.,* 330 *West* 42*nd St., New York* 36, *N. Y.; available from* MACHINE DESIGN, $7.00 *postpaid.*

Subtitled "A Laboratory Reference Text," this fifth edition reflects recent increased emphasis on scientific fundamentals. Particular trends observed are greater use of electrical instruments and transducers and the study of the dynamics of the processes of flow and heat transfer. Fourteen chapters cover report writing, mechanical measurements, electromechanical measurements, automatic controls, lubrication, heat transfer, properties of fluids, fluid dynamics, pumps and compressors, combustion and fuels, steam power, heating and ventilating, refrigeration and cooling, and internal combustion engines.

•

Modern Physics, A Textbook for Engineers. *By Robert L. Sproull, associate professor of physics, Cornell University;* 491 *pages,* 6 *by* 9 *in., clothbound; published by John Wiley & Sons Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.; available from* MACHINE DESIGN, $7.75 *postpaid.*

The aim of this book is to present to engineers those parts of twentieth-century physics which are of greatest importance in engineering. The book describes the modern physics of electrons, atoms and nuclei and applies this basic physics to problems of engineering interest. The two principal applications are to the transistor and to the nuclear power reactor. Other applications are to the electrical,

for HAZARDOUS LOCATIONS

SKINNER EXPLOSION-PROOF Solenoid Valve
Only 3 27/32" high

Skinner X5 Series Explosion-Proof stainless steel Valves are ideal for use in hazardous applications. They are Underwriter Approved for Class I (Gasoline vapors, etc.), and Class II, Groups F (Grain dust) and G (Coal and coke dust), and offer you incomparable simplicity and flexibility of design.

These low-cost valves are expertly engineered to give trouble-free performance through millions of cycles. They're direct-acting, leakproof and spring loaded for operation in any position. Available in a wide range of types, voltages, pressures, flow control adjustments, port sizes and port locations.

SPECIFICATIONS: Type: Two- and Three-Way Normally Open, Normally Closed, and Directional Control; Pressure Range: 0-1000 p.s.i. Orifice Diameters: 3/64" to 1/4". Pipe size: 1/8" or 1/4" NPT; Voltage All AC and DC; Duty Cycles: Continuous or Intermittent. *Write today for Bulletin 526A*

SKINNER

SKINNER ELECTRIC VALVE DIVISION · SKINNER CHUCK COMPANY

THE CREST OF QUALITY

SKINNER · ELECTRIC VALVES ®

SOLENOID VALVES

115 Edgewood Avenue
New Britain, Conn.

WORLD-WIDE REPRESENTATION

—ITEM 664—

. . . now possible with

CALIDYNE'S NEW SHAKER SYSTEMS

Vibration testing under *random* or *"white noise"* conditions probably approximates conditions of *actual* use far more realistically than pure, single frequency testing. But to do this a shaker system must first be designed and built so that all secondary structural resonances are eliminated in the shaker itself. The frequency range must be broad enough to encompass the desired band and the amplifiers must have the capacity to handle the necessary increase in power.

Calidyne can now offer such shaker systems capable of reproducing random noise spectra. In effect, a completely new group of Calidyne shakers and systems is now becoming available to industry and research. Representative of such equipment is the Model 174 Shaker. This "Wide Band" unit is rated for continuous duty at 1500 lbs. force output, over the frequency range up to 4000 cps. Stroke is ±½". The 25 lb. armature approximates a simple, single-degree-of-freedom system over this extended frequency range. A system using the Model 174 Shaker, like others in the new Calidyne line, permits vibration testing under random noise conditions, and should do it in far less time than single frequency environmental tests.

THE CALIDYNE COMPANY

120 CROSS STREET, WINCHESTER, MASSACHUSETTS

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RIDGEWOOD, NEW JERSEY G. C. Engel & Associates Gilbert 4-0878
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CANADA Measurement Engineering Ltd. Arnprior, Ont., Phone 400 Toronto, Ont., Mayfair 8860
EXPORT Rocke International Corp. 13 East 40th St., N. Y. 16, N. Y. Murray Hill 9-0200

—ITEM 665—
For More Information Circle Item Number on Yellow Card—page 19

The Engineer's Library

thermal, mechanical and magnetic properties of solids and to the electrical and chemical properties of surfaces.

New Standards

Inspection of Fine-Pitch Gears, ASA B6.11-1956, AGMA 236.04. 41 *pages, 8½ by 11 in., paperbound; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $2.50 per copy.*

This standard originated with several standards of the AGMA, particularly 236.02, dated Sept. 1948. The present standard has been revised due to advancements in instrumentation for the inspection of fine-pitch gears. New tables have been added giving the settings for a variable center distance gage for the diverse combinations of total composite errors and tooth thickness reduction.

♦

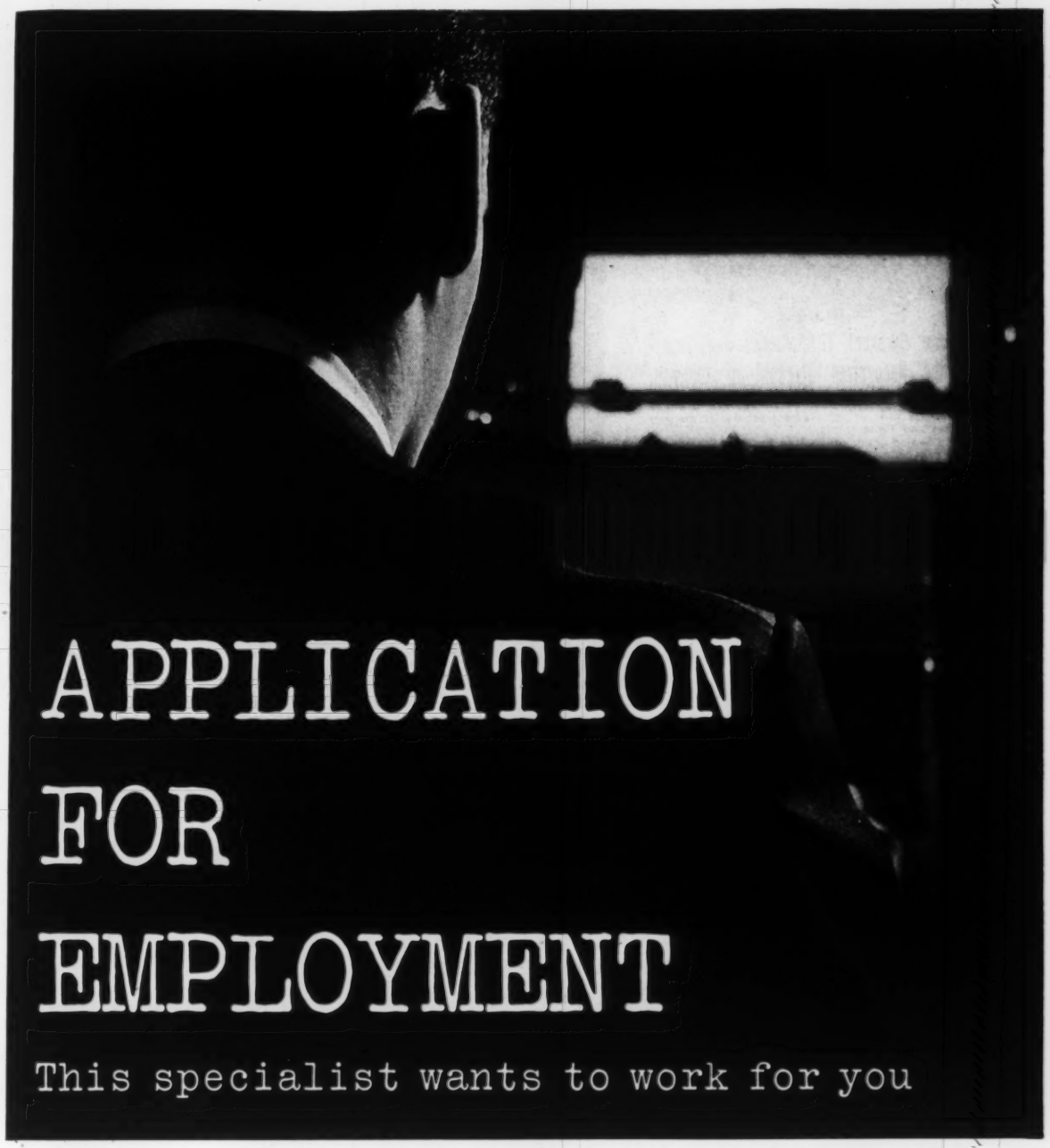
20-Degree Involute Fine-Pitch System, ASA B6.7-1956, AGMA 273.04. 23 *pages, 8½ by 11 in., paperbound; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $1.50 per copy.*

This standard is based on earlier AGMA standards, particularly 207.02. In this revision, a uniform pressure angle of 20 degrees has been adopted. Pinions covered by the main tables have not less than 10 teeth. Pinions with 7 to 9 teeth are treated separately. Provisions have also been made to allow minor changes in addendum and dedendum proportions to meet special design conditions.

Association Publications

Proceedings of The National Conference on Industrial Hydraulics, Vol. IX, 1955. 233 *pages, 6 by 9 in., clothbound; published by and available from National Conference on Industrial Hydraulics, 3300 Federal St., Chicago 16, Ill.; $5.00 per copy.*

Included in this book are the papers presented at the eleventh



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This specialist wants to work for you

Qualifications —Trained assembly engineer. Familiar with all present-day fastening techniques. In daily contact with engineering, production and purchasing departments.

Experience —Can draw on the experience of more than a million applications. Successful record of pointing the way to assembly savings (often up to 50%) in 7 out of 10 cases.

Opportunity Wanted—A chance to study your product (preferably in the design stage) and to make recommendations for speeding assembly, reducing spoilage, improving strength and reducing costs by means of the fast, effective P-K method.

"Tools" —Parker-Kalon, the only complete line of Self-tapping Screws. The right "tool" fitted to every job.

Remarks —No cost or obligation. For details, call your local Parker-Kalon distributor.

PARKER-KALON® *fasteners*

Parker-Kalon Division, General American Transportation Corporation—Clifton, New Jersey
Sold Everywhere Through Leading Industrial Distributors. Warehouse in Chicago, Illinois

—ITEM 666—

20 Years OF OUTSTANDING PERFORMANCE

have made Durakool Tilt-Switches and Timer-Relays the Recognized Standard of Industry.

Now celebrating its 20th year, Durakool, Inc., is proud of the many records of achievement set by its mercury tilt-switches and timer relays.
The basic "Sealed under pressurized hydrogen" principle has been proved on thousands of applications. So successful have they been that they are now the accepted standard of industry:

- ★ Millions of contacts or cycles without faltering
- ★ Outlasts the normal equipment life
- ★ Trouble-free under every practical temperature or humidity condition
- ★ Low cost

See telephone directory for local distributer, or write.

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700 WESTON RD., TORONTO 9, CANADA

Durakool

—ITEM 667—

Another of the Reasons Behind Brad Foote Quality—

METALLOGRAPHY

• The heat treatment a gear receives is probably the most important single factor in determining its long range wear characteristics. Here at BRAD FOOTE we pride ourselves on having equipment designed to provide the widest possible variety of heat treatments.

• But in addition to standard heat treating and testing equipment we have a few extra safeguards. One of these, rather unusual in our business, is a complete Metallographic laboratory. Specialized equipment allows us to examine or photograph the grain structure of all of our metals, in order to determine the most effective methods of heat treatment and to serve as a check on the quality of finished work.

• Metallographic examination is just one of the many reasons behind BRAD FOOTE quality. Prove to yourself the savings this extra quality can mean. Let us quote on the gear requirements for your next program, without obligation.

BRAD FOOTE MAKES ALL TYPES OF GEARS—
IN A COMPLETE RANGE OF STYLES AND SIZES

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Bishop 2-1070 • OLympic 2-7700 • TWX CIC-2856-U

subsidiaries
AMERICAN GEAR & MFG. CO. Lemont, Illinois • Phone Lemont 920
PITTSBURGH GEAR COMPANY Pittsburgh 25, Penn. • Phone SPalding 1-4600

—ITEM 668—

The Engineer's Library

annual meeting of the conference sponsored by the Graduate School of Illinois Institute of Technology and the Armour Research Foundation. The papers cover subjects in the fields of hydraulic fluids, pneumatics, components and accessories, pumps, presses, machine tools, automotive, mobile equipment, aircraft controls, and analog computers.

Government Publications

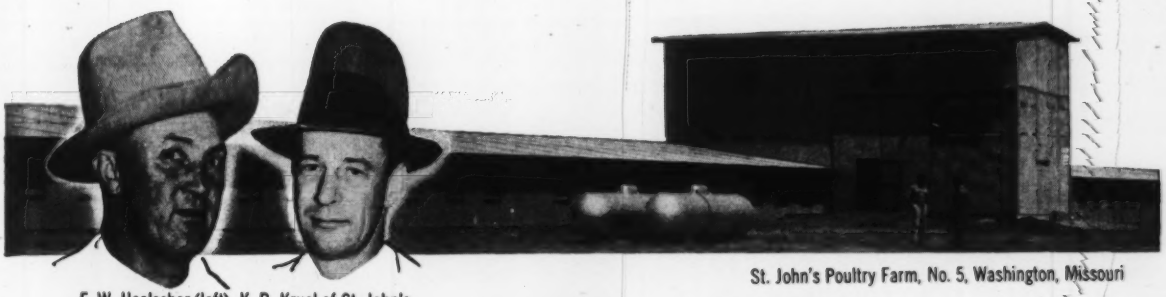
Guide to Instrumentation Literature, National Bureau of Standards Circular 567. *By W. G. Brombacher, Julian F. Smith and Lyman M. Van der Pyl;* 156 *pages,* 8 *by* 10¼ *in., paperbound; published by The National Bureau of Standards; available from the Superintendent of Documents, U. S. Government Printing Office, Washington* 25, *D. C.;* $1.00 *per copy.*

This circular is intended to assist research investigators, instrument users, and others interested in utilizing the extensive literature of instrumentation. The main headings in the Guide are the classes of source literature which include books, periodicals, abstracting and indexing journals, bibliographies, patent office publications, technical reports, directories, indexes of specifications and guides for searchers.

•

Handbook, Preferred Circuits, Navy Aeronautical Electronic Equipment. *By J. H. Muncy;* 204 *pages,* 7¾ *by* 10 *in., paperbound; prepared by National Bureau of Standards for Bureau of Aeronautics, Dept. of the Navy; available from Superintendent of Documents, U. S. Government Printing Office, Washington* 25, *D. C.;* $1.75 *per copy.*

This looseleaf handbook is comprised of two parts: the Preferred Circuits Manual and Notes to the Preferred Circuits Manual. The Manual presents 32 preferred circuits, including voltage regulators, multivibrators, blocking oscillators, video detectors, and amplifiers. Schematics of each circuit are provided, together with characteristics and other information. Suc-

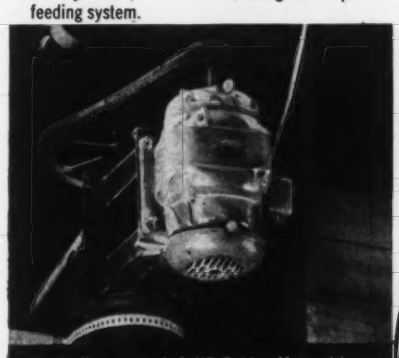


St. John's Poultry Farm, No. 5, Washington, Missouri

F. W. Hoelscher (left), K. B. Kruel of St. John's Poultry Farms, Inc. Hoelscher designed unique feeding system.

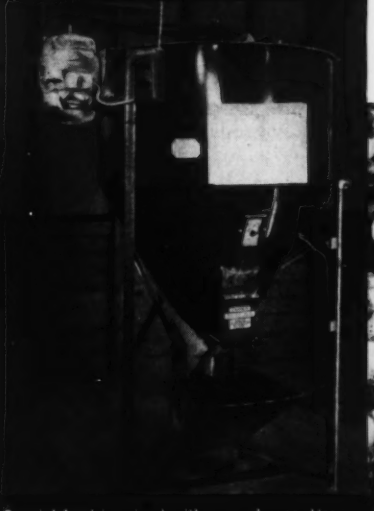
Baldor

STREAMCOOLED MOTORS help feed 120,000 chickens Automatically!



Vertically-mounted, 2-HP Baldor Motor drives screw elevator which lifts corn grain from ground level into hopper for storage.

Hammer mill, powered by a 5-HP Baldor Motor, grinds grain and blows it to weighing bin and mixer.



Special feed is mixed with ground corn. Vertically-mounted, 3-HP Baldor Motor drives mixer. All motors are single phase.

St. John's Poultry Farms, Washington, Mo., boasts one of the most time and labor saving systems for feeding chickens in the world! Six block-and-a-half long broiler buildings house 20,000 chickens each. *One man* maintains each building.

Many Baldor Streamcooled Motors power these automatic feeding systems. Splash-proof, dust-proof, totally enclosed motors keep out powder-like grain that constantly fills the air. Non-clogging external fans can't cause trouble that might stop entire system.

These same rugged Baldor Motors—proven in field use for over a third of a century—have also earned an outstanding reputation among OEM users. Baldor engineering counsel is available—without obligation—to help solve your knotty motor problems. Just contact . . .

BALDOR ELECTRIC CO.

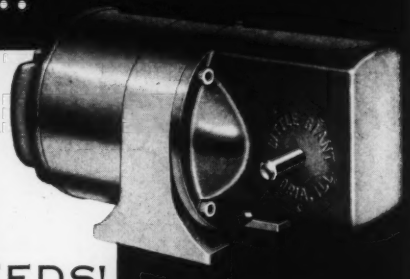
4353 Duncan Avenue • St. Louis 10, Missouri

Chain belt carries feed in adjustable-height troughs to 20,000 broilers. Automatic timer increases frequency of delivery as chickens mature. Human hands never touch grain during entire process.

LITTLE GIANT

Speed Reducers...

Gearmotors...



DESIGNED FOR YOUR SPECIFIC NEEDS!

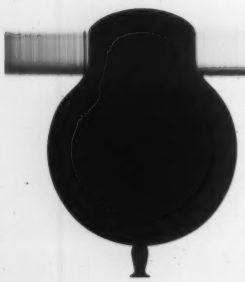
You furnish the specifications—Little Giant engineers will custom-design power transmission equipment to match the application.

Basic components are work-proven standard parts for reduced costs, while housings, mountings, shaft positions and other features are engineered for your specific needs.

There's no cost, no obligation, for this personalized design service. Just submit details of your needs, we will do the rest.

CHECK THESE LITTLE GIANT FEATURES

- Worm integral with input shaft. Worm thread and all diameters hardened and ground from alloy steel.
- Bearings and shafts designed for high overhung loads.
- High efficiencies through use of ground alloy worm and 3½% nickel bronze gear.
- Clean, compact design.
- Speed Reducer ratios: 5-4/5:1 to 100:1 within a 1½" to 2⅝" center range.
- Gearmotors ratings: 1/50 to 1 H.P.



LITTLE GIANT
PRODUCTS, INC.
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Manufacturers of quality products since 1918

—ITEM 670—
For More Information Circle Item Number on Yellow Card—page 19

The Engineer's Library

cessive pages explain use and design methods. The preferred circuits were derived after experimental measurements had been made on a large number of examples taken from both commercial and military electronic equipment. The Notes explain the steps which led to the selection and design of each preferred circuit.

♦

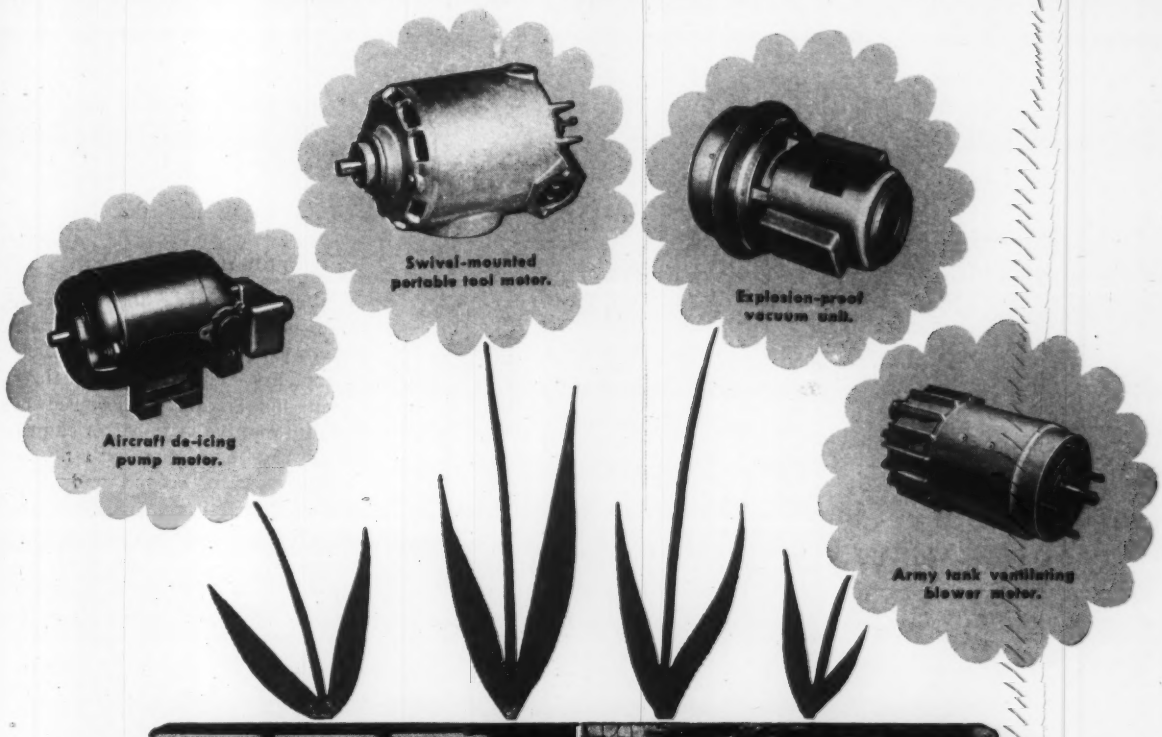
Electrodeposition of Titanium, PB 111798. *By Albert W. Schlechten, Martin E. Straumanis and C. Burroughs Gill, Missouri School of Mines and Metallurgy, for Wright Air Development Center; 57 pages, 8 by 10⅝ in., paperbound; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; $1.50 per copy.*

This report describes a process to obtain a diffusion coating of titanium on iron, mild steel, copper, and other metals. The coating is said to be high in titanium content and to display good corrosion resistance. Many of the variables in the process have been investigated and are reported. Data are also presented on the corrosion of titanium in fused salts, the resulting products, and the probable mechanism.

♦

Copper Wire Tables, National Bureau of Standards Circular 31, 4th Edition. *36 pages, 8 by 10¼ in., paperbound; published by The National Bureau of Standards; available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.; 30c per copy.*

For copper wire in American Wire Gage sizes, these tables give resistivity, temperature coefficient of resistance, a method of calculating per cent conductivity, the density of copper, and the resistivity of hard-drawn copper. The present revision has been prepared at the request of the American Society for Testing Materials. The wire diameters have been rounded to 0.1 mil and the tables are calculated from these values. The tables have been extended to the diameter of 50 gage and to a temperature of 200 C.



Engineering | Placing Leads

OUT OF THESE SKILLS GROW

dependable motors for your product . . .

Out of long experience in the small motor field — in research, engineering and manufacturing — come the dependability and exceptional performance of Lamb Electric Motors.

Our plant is equipped and organized to *custom manufacture* on a volume basis, and our costs are proportional to the quality level your product requires.

Teaming up your engineering department with ours will enable *your* company to profit from these advantages.

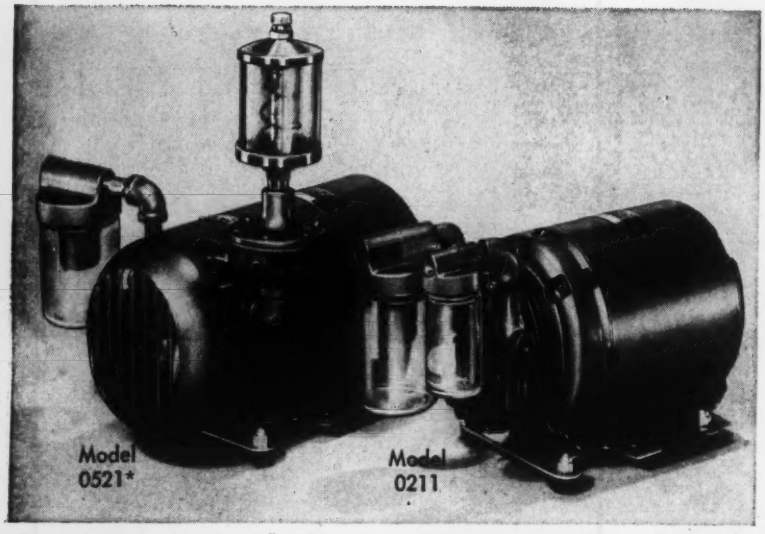
THE LAMB ELECTRIC COMPANY • KENT, OHIO

In Canada: Lamb Electric — Division of Sangamo Company Ltd.—Leaside, Ontario

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

—ITEM 671—

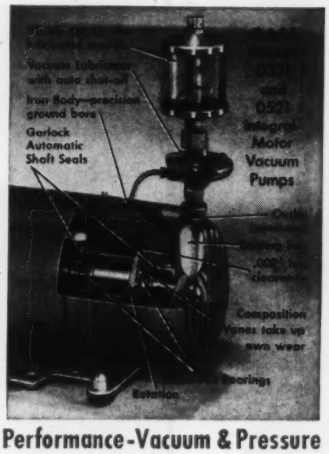


Get 10 Integral-Motor-Pump advantages in two NEW types (three models) of

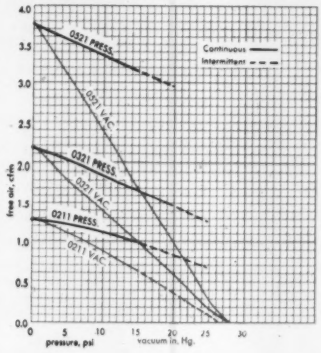
GAST rotary vane AIR PUMPS

Designers seeking a dependable vacuum or pressure source for industrial instruments, vending machines, air gauge circuits, air sampling, laboratory equipment, printing and packaging machinery, etc., will find these *new* Gast Integral-Motor Air Pumps highly advantageous, especially where compactness and portability count. Consider these outstanding features:

1. Latest type G.E. "Form G" motors.
2. More compact than any pump of equal capacity.
3. Total weight reduced ⅓—cuts shipping costs.
4. Motor mounting time and labor eliminated.
5. Simple, trouble-free rotary-vane design.
6. Vanes take up their own wear automatically.
7. Positive displacement, pulseless air delivery.
8. Improved appearance—smoother exterior.
9. Dependable for original equipment; plant use.
10. Forced air fan cooling on Models 0321 & 0521.



Performance-Vacuum & Pressure



Write for new Bulletins V-356 and P-356!

GAST MANUFACTURING CORP.,
P. O. Box 117-P, Benton Harbor, Mich.

*0321 similar in appearance.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

—ITEM 672—

New Machines

Materials Handling

Pallet Truck: Walkie electric truck is designed for pallet handling and is available with a 4000-lb capacity. The truck has three travel speeds and is powered by four automotive type batteries providing 24-v operation with no resistance loss in second and third speeds. Third travel speed affords extra power on dockboards and ramps or for riding on long distance hauls. Batteries can be charged without removal from the chassis. Fingertip controls are provided for travel, lift and lowering. A safety button on the end of the handle puts the truck into the reverse direction when it presses against the operator. *Raymond Corp., Greene, N. Y.*

Tractor Logger: Michigan Model 175 tractor logger is designed to lift 20,000 lb of logs while standing still; at 4 mph it can carry 14,000 lb. Two log clamps can handle one 6-ft diam log or several smaller logs. Hydraulically operated, the clamps close to 16 in. or can be adapted to close completely. Lifting forks 3 ft long can be raised to a height of 11 ft 7 in. and tilted downward at a 39-deg angle to reach over a row of logs for picking up a load. Unit design incorporates a heavy-duty torque converter, planetary wheel drives and steer axles, and power shift transmission which permits the operator to shift from forward to reverse while in motion. Maximum speed is 27 mph. Available in both gasoline and diesel six-cylinder engine models, the machine is 21 ft 11 in. long with forks at carry position. *Clark Equipment Co., Construction Machinery Div., Benton Harbor, Mich.*

Lift Truck: QN-20 Monomast truck with 2000-lb capacity at 24-in. load center has a single-upright mast which affords good visibility in handling loads. Designed for both inside and outside use, the truck can be maneuvered rapidly

Blanks that machine so beautifully

An expert job of finish-machining is possible only when the blank itself is sound. Bethlehem circular steel blanks have the soundness and strength that enable the machinist to work with complete confidence.

Bethlehem's manufacturing process is unique. Combining both forging and rolling, it produces a blank with uniform density and smooth, regular grain flow. The metal is solid and clean, and it cuts away fast. There is no hidden trouble under the surface that might slow the job or cause rejection.

Ask your shop to try these easy-to-work-with blanks. Available in sizes from 10 to 42 in. OD, heat-treated or untreated, they are recommended for gears, crane wheels, clutch and brake drums, sheave wheels, flywheels, pipe flanges, and many other circular steel products.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

—ITEM 673—

CASE HISTORY 1

REQUIRED:

A dependable supply of this small, machined electrode to meet customer's quality and quantity needs at reduced cost.

HASSALL SOLUTION:

Hassall-designed re-heading process, involving no critical dimension changes, resulted in a 59% cost reduction to customer.

CASE HISTORY 106

REQUIRED:

Replacement for stud with insufficient head to act as stop for automatic hammering.

HASSALL SOLUTION:

Substitution of Hassall cold-headed collar stud with annular threads for greater holding power. Substantial cost savings.

SPECIALTY MANUFACTURER OFFERS SAVINGS ON SMALL PARTS AND FASTENERS

CASE HISTORY 64

REQUIRED:

An economical method of manufacturing perforating punches out of hard materials such as drill rod.

HASSALL SOLUTION:

The Hassall cold-heading process plus engineering skill overcame the difficulties presented by these alloys at considerable savings.

Multiply these case histories a thou-

sandfold and you'll get some idea of the variety of tough problems we crack, and the savings we effect for our customers in the course of a year.

Our cold-heading process—supplemented by secondary operations—imposes amazingly few limitations on the parts and fasteners we can make. Don't forget that we are not limited to "stock" sizes. These illustrations show that Hassall—a specialty supplier — can show you substantial savings, better deliveries and technical assistance on your small parts and fasteners.

Proof? Send us your specifications or write for catalog.

John Hassall, Inc., P. O. Box 2197 Westbury, Long Island, New York.

CASE HISTORY 37

REQUIRED:

Bumper bolt with bonded rubber cap for license plate support.

HASSALL SOLUTION:

The large head on this bolt would ordinarily call for screw machining but the two lugs under the head ruled this out. Progressive cold-heading was Hassall's answer.

HASSALL

SINCE 1850

NAILS, RIVETS, SCREWS AND OTHER COLD-HEADED FASTENERS AND SPECIALTIES

New Machines

in narrow aisles and crowded areas. It is powered by a heavy-duty, air-cooled gasoline engine and is equipped with pneumatic tires for good performance on all surfaces. *Hyster Co., Portland, Oreg.*

Metalworking

Lathe: DV 59 high-speed precision lathe provides spindle speeds variable from 230 to 3500 rpm. Speed changes are power operated from a control box over the headstock; an indicator shows exact speed at all times. Ball-bearing, lever-operated collet closer makes possible the opening or closing of a collet or step chuck with the machine in operation. Collet tension is adjustable from light to heavy holding power. *Hardinge Brothers Inc., Elmira, N. Y.*

Cut-Off Machine: Electrocut solenoid-operated automatic unit cuts bare and insulated wire, spaghetti tubing and plastic tubing to predetermined lengths from ¾ to 13 in. It provides repeat accuracy of ±1/32-in.; greater accuracy can be obtained with slight modifications from the standard unit. Material is drawn directly from the spool and is cut automatically until the spool is empty, at which time the machine shuts itself off. It cuts off material equivalent to ⅛-in. diam mild steel wire at rates from 60 to 150 per minute, depending upon length of the cut-off stroke. Actual diameter to ⅜-in. can be handled. It can handle any spool where the required pull does not exceed 3 lb. Material is fed in steps of 4, 8, 12 or 24 fpm. *Black & Webster Inc., Newton, Mass.*

Tool Grinder: Style 48-B double-end tool grinder performs wet or dry face grinding of large, single-point tools. It can be used for roughing out all sizes of shanks and will recondition tools of high-speed steel, cast alloys and carbides with the addition of suitable wheels. The machine uses two 10-in. plate-mounted wheels. Wheel shaft rotates in heavy-duty, double-row ball bearings, permanently lubricated and sealed against entry of dirt and abra-

Accurate Universal Joint Engineering Assistance—

—Available for Design Engineers

MECHANICS Roller Bearing UNIVERSAL JOINTS *accuracy* has met every aircraft need of the largest bomber and the smallest helicopter. When strategic aircraft requirements indicated a NEW type of universal joint, MECHANICS engineers developed it. Design, metals, machining, tolerances, heat-treating, hardening, stamina, balance and lubrication—all were adapted to aircraft precision. Design engineers may have the benefit of this universal joint know-how by sending for the aircraft bulletin shown at the right. Our general catalog, containing helpful universal joint engineering data and tracing kits, also will be sent to engineers, upon request. Let MECHANICS engineers help design and build universal joints that are exactly suited to the power transmission needs of *your* product. The competitive advantages that designed-for-the-job MECHANICS Roller Bearing UNIVERSAL JOINTS provide, are well worth investigating.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2032 Harrison Avenue, Rockford, Illinois

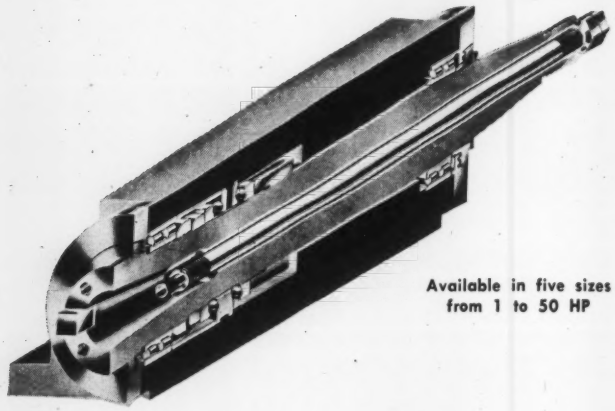
MECHANICS
Roller Bearing B-W
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

Your BEST PACKAGED BUY in milling spindles

POPE

HEAVY DUTY PRECISION SPINDLES

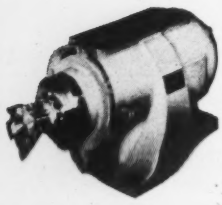


Available in five sizes from 1 to 50 HP

P-12000 Series *Belt Driven* in sizes from 1 to 50 HP, with Standard milling machine tapers in the nose from #10 to #60. *Operable in any position you specify.*

See: the big shaft, the heavy duty double row cylindrical roller bearings and thrust bearings that have extra ability and the rigidity to support your cutting tools.

For complete dimensions, write for Bulletin S-8.



POPE HEAVY DUTY MOTORIZED MILLING MACHINE SPINDLES are available in P-2500 Series, from 1 to 100 HP, totally-enclosed, fan cooled; also in high cycle, water cooled units.

You can specify POPE PRECISION SPINDLES with Confidence No. 110

Specify **POPE** PRECISION SPINDLES — POPE MACHINERY CORPORATION

New Machines

sive particles. Spindle drive is through a V-belt from a reversible motor in the base of the grinder. Tool-rest tables are adjustable to required tool sharpening angles and may also be adjusted to compensate for wheel wear. Heavy sheet metal guards, attached to the table brackets and moving with them, prevent tools from dropping into wheel recesses. Pressure coolant system with tank and pump is provided with the grinder. Coolant at each wheel is controlled by an individual valve and splash guards prevent waste of coolant when the grinder is in operation. Protractor tool guide, universal adapter for grinding the top rake of tools, diamond wheel dresser and tool holders for round and square tools are also available. *Ex-Cell-O Corp., Detroit.*

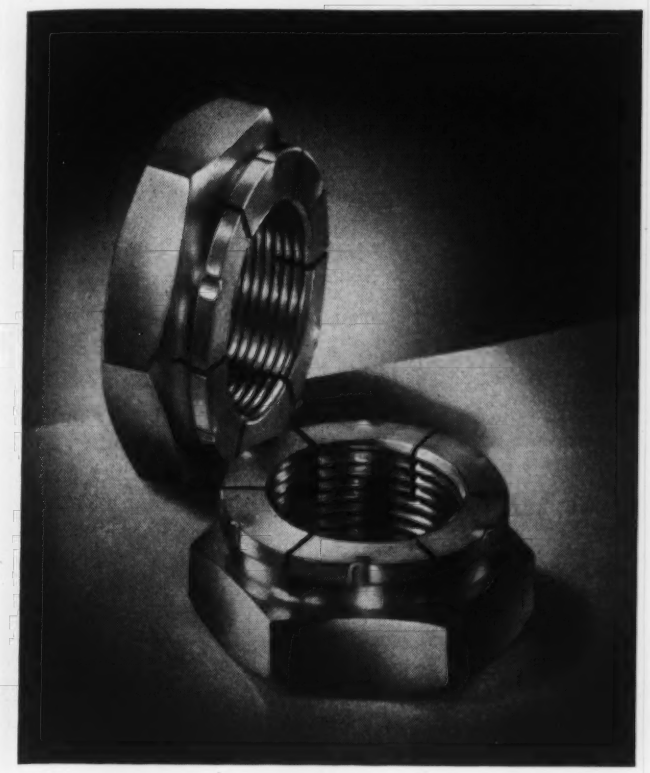
Automatic Lathes: Three platen type, automatic, cam-operated lathes perform a variety of work. They are designed with large swing capacity, high spindle speeds, multiple tooling and fast cycling operation, and are available with 5, 20 and 40 hp capacities. Tool blocks are mounted on a power-operated cross slide. Cross slide base is keyed and bolted to the platen and is adjustable longitudinally by tee slots for quick positioning. Automatic longitudinal feed for the platen is obtained through a barrel cam housing in the bed of the machine. Swing over the platen in the three models is 11, 18 or 24 in. *Seneca Falls Machine Co., Seneca Falls, N. Y.*

Office Equipment

Electronic Computer: Combination digital computer and digital differential analyzer solves linear and nonlinear differential equations in problems of research and control. Flexible programming system permits the creation of simplified interpretive subroutines which allow persons without previous computer experience to prepare problems for solution. All operations are controlled from an electric typewriter mounted on a base containing control elements. The keyboard can be used to enter information directly into the com-

—ITEM 676—
For More Information Circle Item Number on Yellow Card—page 19

Flexloc thin nuts save space, weight and production time



Self-locking nuts are 30% lower and lighter; speed up assembly with hand or power tools

Self-locking FLEXLOC thin nuts are 30% lower than regular height locknuts of the same nominal diameter. They fit into spaces where regular height locknuts will not go. You can design lighter, more compact units with them.

Where you must reduce weight in a completed assembly, you can save by using shorter bolts with these lighter nuts. And you save production time. The length of engagement of mating threads is shorter: fewer revolutions of hand wrenches or power nut runners are needed to seat them.

FLEXLOC nuts are of 1-piece, all-metal construction. You can use a FLEXLOC fully seated as a locknut or at any point along a bolt as a stop nut. Once the threads in the resilient locking section are fully engaged, the FLEXLOC grips the mating threads with uniform locking torque wherever wrenching stops. Since there are no nonmetallic inserts to come out or deteriorate, the locking life of a FLEXLOC is virtually unlimited.

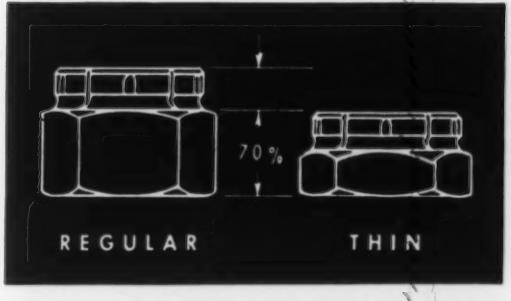
Your authorized industrial distributor stocks FLEXLOC nuts in a variety of sizes, materials and finishes. Consult him for details. Or write us for information about your special locknut problem. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

SPECIFICATIONS
FLEXLOC THIN NUTS

NATIONAL COARSE THREAD—U.S.S

SIZE	A INCHES	H INCHES	WIDTH ACROSS CORNERS	WEIGHT PER 1000 NUTS
6-32	.312	.125	.361	1.8
8-32	.344	.172	.397	2.8
10-24	.375	.172	.433	3.3
¼-20	.438	.203	.505	5.4
5/16-18	.563	.250	.649	11.6
⅜-16	.625	.265	.722	14.9
7/16-14	.750	.312	.866	24.9
½-13	.813	.312	.938	28.4
9/16-12	.875	.359	1.010	36.1
⅝-11	1.000	.391	1.155	54.1
¾-10	1.125	.406	1.299	69.2
⅞-9	1.312	.469	1.516	107.5
1-8	1.500	.563	1.732	171.6
NATIONAL FINE THREAD—S.A.E.				
6-40	.312	.125	.361	1.8
8-36	.344	.172	.397	2.8
10-32	.375	.172	.433	3.3
¼-28	.438	.203	.505	5.4
5/16-24	.500	.250	.577	8.7
⅜-24	.563	.266	.649	11.5
7/16-20	.625	.312	.722	14.9
½-20	.750	.312	.866	21.7
9/16-18	.875	.359	1.010	36.2
⅝-18	.938	.391	1.082	42.4
¾-16	1.063	.406	1.227	54.5
⅞-14	1.250	.469	1.443	84.6
1-14	1.438	.563	1.660	136.3
1⅛-12*	1.625	.625	1.876	193.5
1¼-12*	1.813	.750	2.093	296.0
1⅜-12*	2.000	.812	2.309	389.0
1½-12*	2.187	.875	2.526	498.0

*Steel only (plain or cadmium plated) in stock sizes.



FLEXLOC thin nuts are 30% lower than regular height locknuts. There is a corresponding saving in weight. In sizes through 5/16 in., thin FLEXLOCS meet tensile strength requirements for regular height locknuts. FLEXLOC nuts can be made in the thin type because every thread, even those in the locking section, carries its full share of the load. There are no nonmetallic inserts to waste head space or weaken the structure of the nut.

Standard FLEXLOC self-locking thin nuts are available in plain or cadmium plated alloy steel, for use in temperatures to 550°F; in plain or silver plated corrosion resisting steel, for temperatures to 750°F; and in brass and aluminum, for temperatures to 250°F.

STANDARD PRESSED STEEL CO.
FLEXLOC LOCKNUT DIVISION SPS
JENKINTOWN PENNSYLVANIA

—ITEM 677—

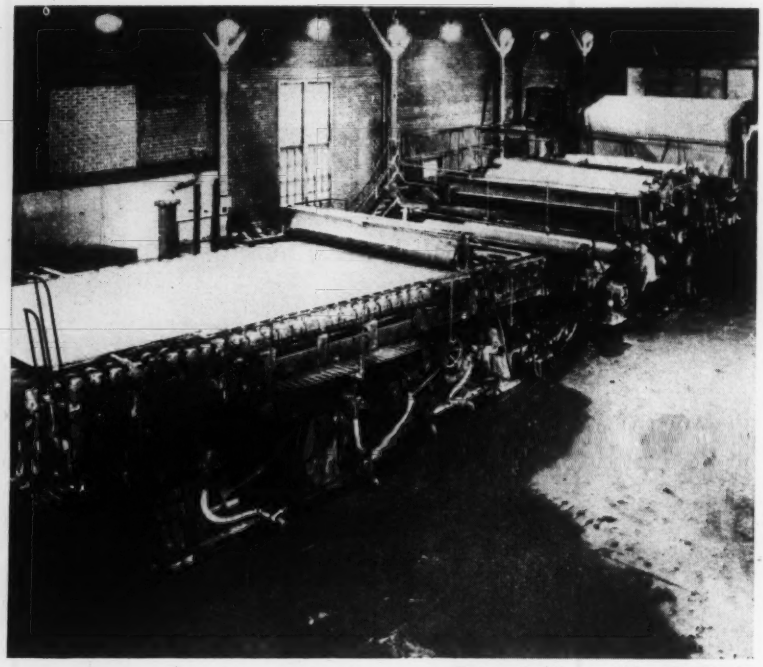


Photo courtesy Hammermill Paper Co., Erie, Pa.

Continental's Rubber Rolls at Work on Hammermill Bond

Only with the highest degree of technical skill and accuracy which Continental builds into its rubber covered rolls can the critical specifications of the paper industry be met.

These rubber covered rolls must have long wearing qualities, uniform density and a precise crown to give the months of *trouble-free* service required.

The rolls actually squeeze water from the paper as it passes through the nip of the roll. Specifications engineered into these rubber covered rolls minimize the possibilities of wet spots, strength variation, or breaks in the paper—thereby eliminating costly shutdowns.

The successful production of these rubber covered rolls typifies the complete engineering and laboratory—as well as manufacturing—service offered by Continental.

Regardless of your rubber requirements, whether rubber covered rolls or any type of molded or extruded parts, call Continental. Their engineers will be glad to consult with you in the planning or blueprint stage to help you get better engineered rubber for all your needs. You'll like the service you get.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

—ITEM 678—
For More Information Circle Item Number on Yellow Card—page 19

puter and also can tabulate output. Input or output operations up to 108 words can be initiated by one command. This operation proceeds to completion without intervention while the machine continues to compute with full efficiency. Electric typewriter input and output, high-speed photoelectric paper tape reader and paper tape punch are standard equipment. Up to four magnetic tape units, each with 300,000 word storage, a graph plotter and follower are available as accessory equipment. *Bendix Aviation Corp., Bendix Computer Div., Los Angeles.*

Dictating-Transcribing Machine: Model 556R is an automatic, lightweight tape machine which can be used for both dictating and transcribing. It also records up to 1 hr on a 5-in. reel of magnetic tape. Separate foot pedal permits instantaneous start or stop, playback, winding, erasing and editing. A separate headset is provided for transcription. The machine is portable, weighs 16 lb. *Telectro Industries Corp., Long Island City, N. Y.*

Packaging

Weighing Machine: Redesigned Heavi-Weigh unit with 5 to 100 lb capacity is used for net weighing a variety of dry materials such as foods, chemicals, plastics and drugs. It consists of four basic elements: A supply hopper, an electric vibratory feeder, a weigh bucket mounted on a weigh beam, and an electrically operated gate. Material is uniformly conveyed from hopper to weigh bucket. When a predetermined weight of material is reached in the bucket, the weigh beam moves, cutting off the material flow. At a set time, the gate opens to discharge the weigh bucket. The machine charges any type of container such as bags, boxes, cans, jars and molds. *Glengarry Processes Inc., Bay Shore, N. Y.*

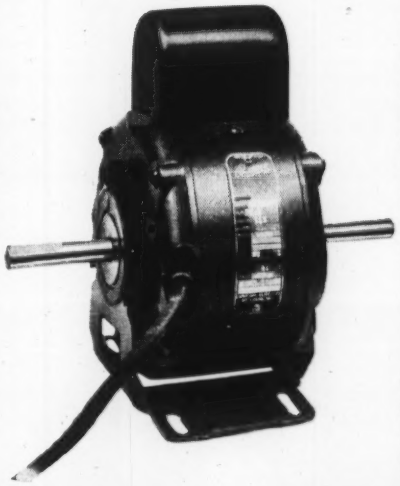
Strapping Machine: Electric girth strapper, designated No. 401, straps, bundles and reinforces on an assembly line basis. It applies approximately 700 straps per

More POWER with Less Amps!

Century

Performance-Rated®

FAN MOTORS



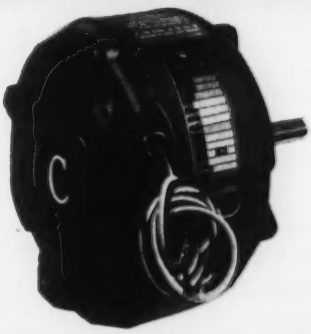
HELP SOLVE YOUR LOAD AND POWER FACTOR PROBLEMS

In air conditioning or ventilating equipment, you can reduce starting current, reduce running current and increase power factor with these new Century Fan Motors. They are Performance-Rated for air conditioning manufacturers who are faced with new load and power factor problems. Fan manufacturers find advantages in their short length, light weight, multi-speeds and easy reversibility.

In your product and in your plant, Century Motors are Performance-Rated to fit your needs. For information, call your nearby Century Sales Office, or write us direct.

Type C, Permanent Split Capacitor . . . round frame, single speed, reversible—also available with cushion mounting.

Type CM, Permanent Split Capacitor . . . round frame, 2 or 3 speeds, all reversible—also available with cushion mounting.



CE-75

Performance-Rated®
1/8 to 400 H. P.

C CENTURY ELECTRIC COMPANY

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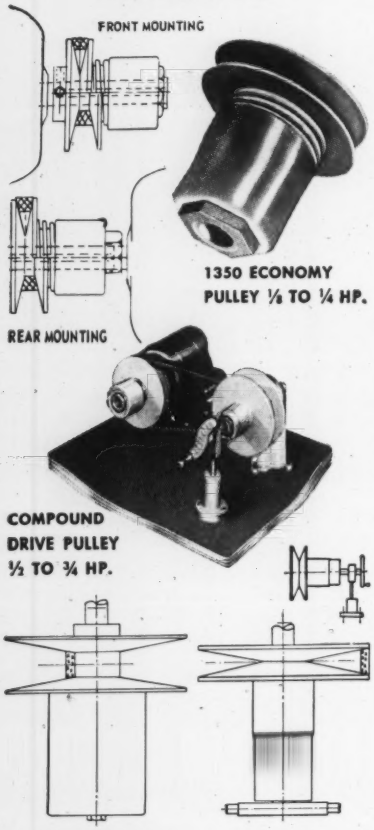
—ITEM 679—

Lovejoy

Fractional Horsepower

VARIABLE SPEED PULLEYS



Economical—
low in initial cost . . . easily installed on old or new equipment.

Minimum Maintenance—
simple construction assures trouble-free operation . . . lifetime lubricated with oil-impregnated bronze bushings.

Constant Belt Alignment—
inner and outer pulley sheaves open equally to provide smooth, infinitely variable speed ratios to 8 to 1.

No Slippage—
Sure grip of belt sides delivers full traction under all load conditions...result is greater horsepower carry capacity.

Get the new 12-page Lovejoy catalog! Write today.

LOVEJOY FLEXIBLE COUPLING CO.
4818 W. Lake St., Chicago 44, Ill.
—ITEM 680—

New Machines

hour, automatically compressing the material to be strapped. Complete wrap is applied automatically. Uses include closing and reinforcing overlap-flap slotted containers; bundling prefabricated finished woods, milled lumber, sheet metal, extruded parts, rods, tubing, cores and dowels; and reinforcing cartons containing high weight loads. Machine handles packages 4 x 4 in. to 12 x 12 in. of unlimited length. It is adjustable to handle either hard or soft materials and square or irregular shapes. Machine is powered by a 110-v, single-phase ac, ¾-hp electric motor. Tape application is single wrap with overlap. Strapping and cloth tapes from ¼ to 1 in. wide can be used. *Permacel Tape Corp., New Brunswick, N. J.*

Processing

Die Casting Machine: Model 400-N die casting machine is available with either a cold chamber shot end for casting aluminum, brass and magnesium alloys or hot chamber shot end for casting zinc, lead and tin alloys. Castings range in size from very small parts produced in multiple cavity dies to single castings weighing up to 7.2 lb in aluminum or 14.5 lb in zinc. Locking pressure of 400 tons is strain gage tested. The machine has a heavy, one-piece steel base in which the 100-gal-capacity hydraulic reservoir is located. Automatic timing control panel provides all desired cycles. Motor is 20 hp, 1200 rpm. A hand control valve stops die movement at any location. Die stroke is adjustable by a wrench adjustment. Die thickness range is from 6 to 26 in.; size of die plates, 36 x 40 in. *Cleveland Automatic Machine Co., Cincinnati.*

Vapor Degreaser: Automatic unit combines vapor degreasing with a cool dip rinse to degrease and wash off chips and other insolubles in one operation. Liquid solvent rinse goes into holes and recesses in the work pieces. Work is cooled so that in each complete cycle there are two separate condensing vapor stages. Work baskets are used for parts relative-

FOR ACCURATE PUMPING

Halliburton Oil Well Cementing Company uses VIKING PUMPS

"The fact that Viking Pumps will consistently deliver in direct proportion to their speed makes them a valuable asset to our sand proportioner units", Halliburton comments.

Used as metering pumps, Vikings deliver fluid into the mixing tank of the unit, where it is properly blended with the correct amount of sand for hydraulic oil well fracturing service.

It is the first practical design for such work and is made possible by accurate Viking pumping. From one to four Viking 450 G.P.M. at 260 R.P.M. pumps are used with Halliburton equipment.

If you have a problem where metering, blending or other accurate pumping of liquids is concerned, let Viking help you solve it. Write for information and Bulletin 565h.

VIKING PUMP COMPANY Cedar Falls, Iowa, U.S.A.

In Canada, it's "ROTO-KING" pumps

THE ORIGINAL "GEAR-WITHIN-A-GEAR" ROTARY PUMP

—ITEM 681—

Westinghouse
Protects Its Quality with
KLIXON Motor Protectors

Westinghouse, one of the world's leading manufacturers of motors and electrical products, has long been known for quality. And to further assure the utmost in dependability and trouble-free operation of its fractional H.P. motors, they incorporate a built-in Klixon Protector in their Thermoguard* motors.

Here's what Mr. J. F. Farrell, Sales Manager, Industrial Motor Department, has to say about Klixon Motor Protectors:

"Modern living has promoted a multitude of uses for fractional horsepower electric motors. Many of these motors are hidden from view and are relatively inaccessible. They must give dependable automatic service under all operating conditions. The Klixon Motor Protector, used on Westinghouse Thermoguard* protected motors gives this full automatic protection against all conditions that might cause motor overheating".

You, too, can keep motors in your equipment working dependably by specifying and using Klixon protected motors. They will reduce maintenance costs, service calls and repairs and replacements. The additional cost is low. The benefits are exceptionally worthwhile.

*Thermoguard is the Registered Trademark of Westinghouse Electric Corporation

KLIXON®

METALS & CONTROLS CORPORATION

SPENCER THERMOSTAT DIVISION

3206 FOREST STREET, ATTLEBORO, MASS.

—ITEM 682—

WANTED

Technical Editor

A challenging opportunity to gain a broad knowledge of the design engineering field.

- Edited for engineers, by engineers, MACHINE DESIGN has an opening on the editorial staff for a man with enthusiasm for both engineering and writing.
- He will work on a stimulating job that provides interesting contact with diversified problems in a variety of engineering areas.
- Additionally he will be encouraged to progress as a specialist in one or more of the branches of design engineering.
- He should have had some design experience, and an EE or ME degree would be desirable.
- He should be able to write fluently and well, and should show evidence of such ability.
- Duties include the procurement, selection, writing and editing of articles and feature departments.
- Headquarters are in Cleveland, with opportunities for travel to attend meetings and expositions and to seek material for publication.
- If you are interested and feel qualified, send full details of your engineering and writing experience to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

ly free from recesses and which do not nest easily. The unit is available with tumblers which provide thorough cleaning action for recessed parts. Time cycles are adjustable. The unit is available with capacities from 1800 to 4000 lb per hr and in gas, steam and electrically heated models. *Phillips Mfg. Co., Chicago.*

Testing and Inspection

Leak Detector: Type 24-210 portable unit is employed to test for minute leaks, to locate them and to determine rate of leakage. The machine can be used in both evacuated or pressurized systems. A mass spectrometer, it responds only to the presence of helium as a tracer gas, and detects one part of helium in 300,000 parts of air. The tester uses printed circuits and six vacuum tubes. Operating controls and electronic components are accessible from the front of the unit. Applications include testing hermetically sealed parts, refrigeration units, high-vacuum systems, drums and other containers. The tester operates at 105/125 v ac. *Consolidated Electrodynamics Corp., Pasadena, Calif.*

Creep Rupture Tester: Multiple creep rupture testing machine is of the lever type in which four specimens can be held simultaneously under loads up to 4000 lb. Four-specimen electric furnace, under automatic temperature control by a single-point indicating and recording controller, will hold specimens at any temperature up to 1800 F. Voltage adjuster of 7 kva capacity is used for furnace control. Running-time counters totalize to 10,000 hr in 0.1-hr intervals. Compound lever system gives a load ratio of 50:1. Specimens can be loaded in increments of 5 lb. A dashpot in each of the lever systems prevents transmitting shock and recoil from a breaking specimen to other specimens under test. Furnace and grip assemblies are in the front of the unit; controls and recorder are on a rear panel. Test bar grips have ¾-in. diam heads, and ½-in. diam shanks. *Baldwin-Lima-Hamilton Corp., Philadelphia.*

RELIANCE DRIVES NEW MILLING MACHINE

This unique milling machine designed for milling big aircraft parts operates exactly like a huge arm. Its cutter swoops in and out at the touch of the joy stick control. The direction in which the stick is pushed is the direction of the head movement. The harder the push the faster the movement.

This unusual feed drive is made possible by a Reliance V★S Drive. Two 7½ hp. Variable Speed D-c. Motors, one each at shoulder and elbow, provide the flexible arm-like feed movements. The motors are controlled and directed by the joy stick.

The result is an extremely compact and versatile feed drive that gives eye-popping performance. Economical in original cost, these Reliance Drives will provide years of steady service with little maintenance.

If you are designing, building or buying machine tools, it will pay you to check the economies of Reliance Variable Speed Drives. A-1616

Write for Bulletin D-2311

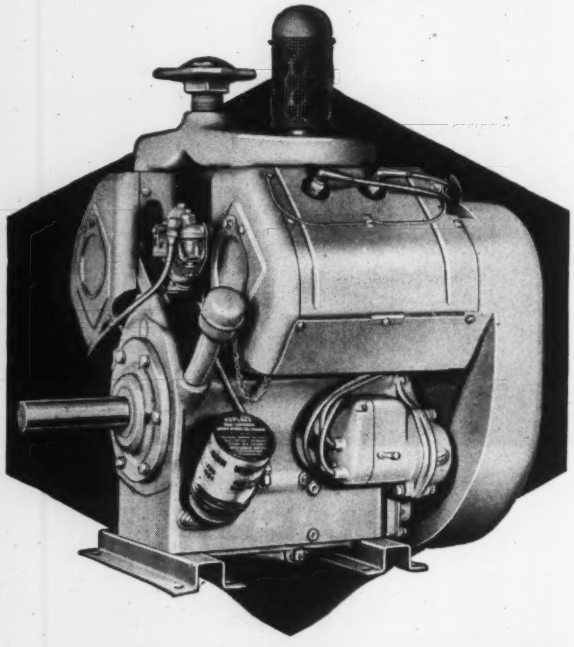
RELIANCE V★S DRIVE ®

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 286A, CLEVELAND 10, OHIO • CANADIAN DIVISION: WELLAND, ONTARIO
Sales Offices and Distributors in Principal Cities

The tiny ant has strength and stamina far out of proportion to its size . . .

HEAVY-DUTY POWER CAN BE PACKED INTO SMALL SPACE, TOO!



WISCONSIN

Heavy-Duty Air-Cooled

ENGINES

Shown here is the largest engine in the Wisconsin line . . . the 36 hp. Model VG4D. This compact, heavy-duty power package has incorporated in its design and construction all the heavy-duty features that make it comparable in rugged stamina and performance dependability to heavy-duty engines of much greater size.

The 11 other models, ranging from the 2.3 to 5.6 hp. Model ACN 4-cycle single cylinder engine, to the Model VF4, 25 hp. V-type 4-cylinder are similarly so compactly power-packaged that these engines can be fitted to *your* equipment with a minimum of re-designing—backed by authorized service throughout the world.

Complete specifications and engineering data gladly supplied. Write for Bulletin S-188.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN

A 8750-½

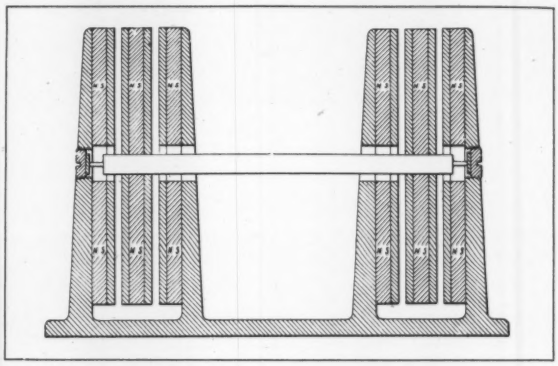
—ITEM 684—

For More Information Circle Item Number on Yellow Card—page 19

NOTEWORTHY Patents

Magnetic Shaft Suspension

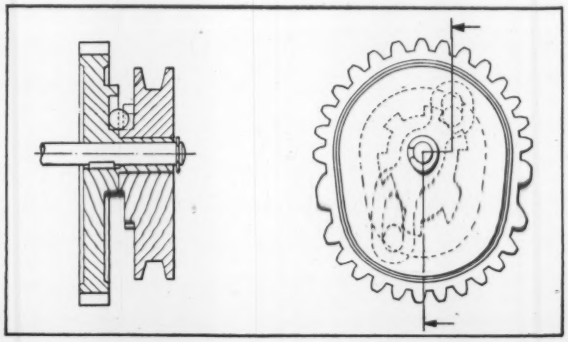
Horizontal mounting of rotating instrument type shafts is accomplished without conventional bearings in a support system based on magnetic principles. Support forces are obtained at each end of the shaft by an assembly of three disk-shaped permanent magnets made of material having high coercive force characteristics and magnetized in the axial direction. The center magnet is mounted to the shaft and is held in suspension by the outer magnets which are attached to the support base. The magnets are ar-

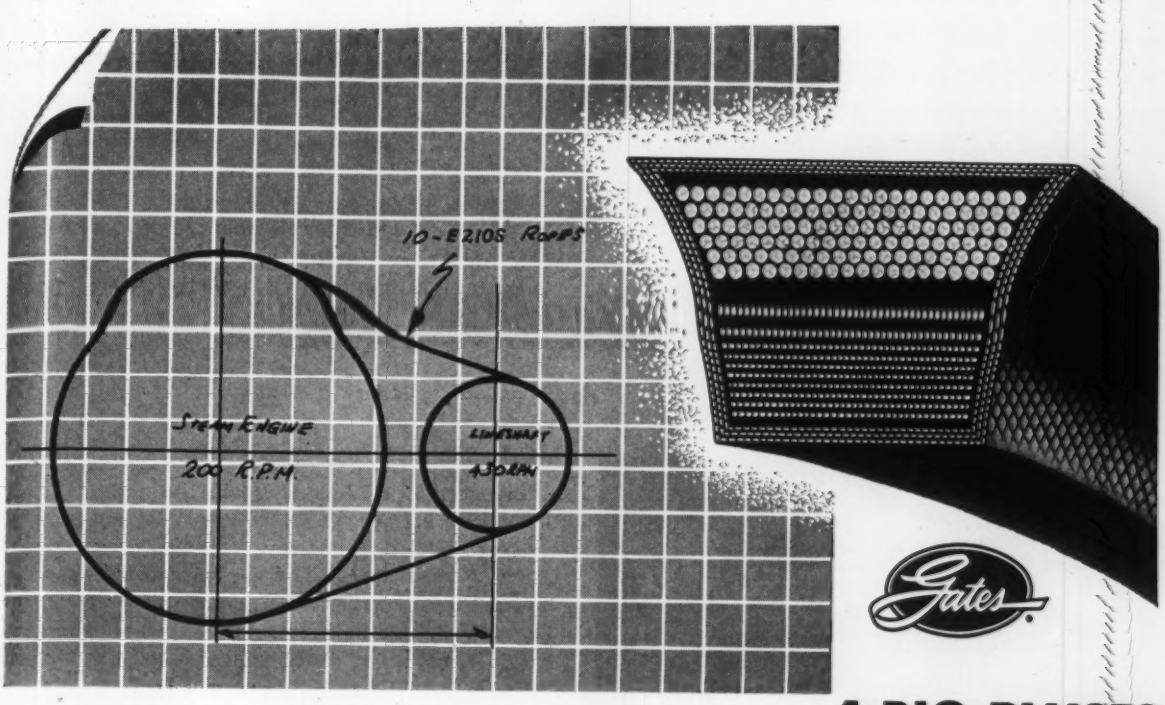


ranged so that opposite poles are adjacent, thus providing an attractive force that tends to keep the disks in axial alignment. Axial motion of the shaft is prevented by threaded end thrust surfaces which permit accurate adjustment of the position of the shaft and the center magnet. Locking torques and rotational hysteresis are minimized by disk shaped "flux distributors" of high-permeability, low coercive force material covering the working faces of the magnets. *Patent 2,725,266 assigned to General Electric Co. by Lewis I. Mendelsohn.*

Overrunning Clutch

Engagement and disengagement of a one-way clutch is controlled by balls mounted to roll freely in slots in one face of the driving member. The balls travel in slots at 45 degrees to the radial clutch axis. As





MORE HP DELIVERED PER $ INVESTED

On any new drive design—where you have limited space or you need to keep weight down—here is an important fact that can save you money:

A Gates Super Vulco Rope drive will deliver more horsepower per dollar invested than any standard V-belt drive.

Actually, the greater load carrying capacity of Super Vulco Ropes cuts down the number of belts required (5 Super Ropes do the work of 7 standard belts) . . . thus reducing the width of sheaves.

Sheaves with fewer grooves not only cost less, they weigh less, and take up less room—advantages that can easily improve the design and lower the overall cost.

A wealth of drive data is quickly available to you. Simply call your nearby Gates V-Belt Distributor (see 'phone book yellow pages) for a Gates V-Belt Specialist. Stocks available in industrial centers around the world. The Gates Rubber Co., Denver, Colorado—*World's Largest Maker of V-Belts.*

4 BIG PLUSES

✚ Handles shock loads

Super-strength cords provide 40% greater horsepower capacity . . . easily absorb heavy shock loads.

✚ Wears far longer

Concave Sidewalls (Fig. 1) increase belt life. As belt bends, concave sidewalls (U.S. Pat. No. 1813698) become straight, make uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt . . . longer V-belt life.

Flex-Weave cover (U. S. Pat. No. 2519590) provides greater flexibility with far less stress on fabric. Cover wears longer—increases belt life.

✚ Provides Static Safety

High electrical conductivity is built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

✚ Resists oil, heat and weather

Special rubber compounds with which cords and fabric are impregnated make Super Vulco Ropes highly resistant to heat, oil and prolonged exposure.

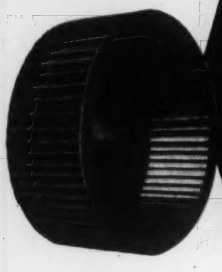
TPA 76

Gates Super Vulco Rope Drives

Specify GARDEN CITY FANS!

Standard Steel Plate Exhauster

Design B Multiblade (Forward Curved)



There's a DEPENDABLE FAN for every need

Does your problem involve efficient movement of air? Garden City can help you. For over 75 years they have maintained leadership in the industrial fan field. Three of the many reasons for their superiority: heavier construction, more advanced design, lower maintenance cost. Garden City's high temperature fans (850 to 1650°) are constructed of finest heavy gauge nickel-alloy steels. The radial, forward and backward curved wheels are abrasion and corrosion resistant to a high degree.

Garden City's air cooled shafts on their heat fans increase bearing life. Consequently, the bearings remain maintenance-free longer.

Send your O.E.M. specifications to Garden City's engineers. Their experience may be of help.

Write today for free brochure giving full information.

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ESTABLISHED 1879

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Representatives in Principal Cities

• Fans for Industry • Backward Curve • Forward Curve
• Material Handling • Radial Bladed • Small Exhaust

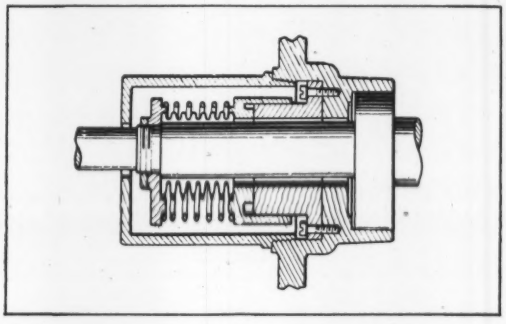
—ITEM 686—

Noteworthy Patents

the driving member rotates, the balls, which may vary in number, engage teeth in a ratchet wheel on the driven member. In one direction of rotation, the forces applied by the ratchet teeth drive the balls to the bottom slot position, locking the two members in engagement. When direction of rotation is reversed, however, the force reaction is opposite, causing the balls to move outward and disengaging the clutch members. *Patent* 2,718,948 *assigned to Eastman Kodak Co. by Robert J. Roman.*

Shaft Seal

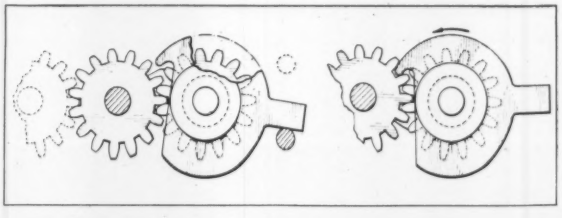
Liquid-tight sealing of submerged rotating shaft assemblies subject to flexure is accomplished with a bellows seal. A cylindrical rotating sleeve, counterbored to fit over a stationary tubular member through which the shaft projects, is connected to a collar on the shaft by a flexible metal bellows. Sealing engagement between the rotating sleeve and the tubular member is maintained by a helical spring that encloses



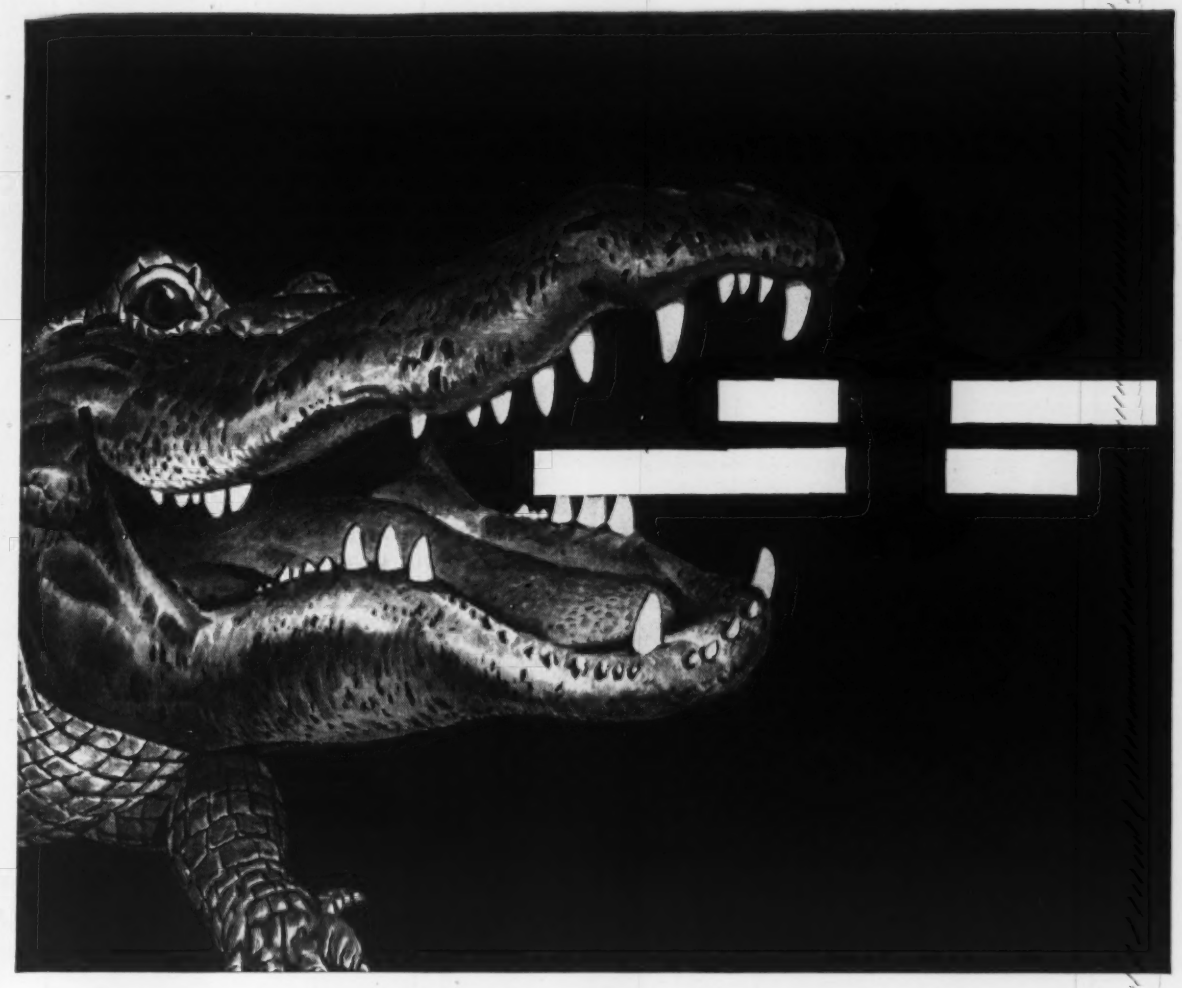
the bellows and is backed up against the collar. Clearances between the shaft surface and the tubular and sleeve members permit transverse shaft flexure during operation. Shaft deflections are accommodated by the bellows while the counterbored "skirt" on the sleeve maintains alignment of the tubular and sleeve elements. *Patent* 2,719,738 *assigned to U. S. Electrical Motors Inc. by Thomas G. Myers.*

Motion Control Mechanism

Correct direction of rotation in low-power gear drives designed for one-way motion is assured by a pawl type arresting mechanism. The device can be used to control any gear in a train and consists of a gear and a disk-shaped pawl member mounted to turn



freely on a bushing on a countershaft. The gear member is meshed with the train gear and drives the pawl through frictional face contact. Angular motion of the pawl is limited by pin stops. In one direc-



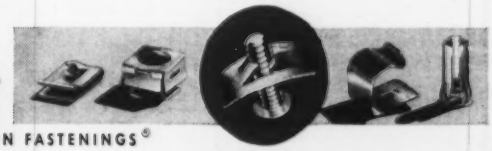
STEEL JAWS THAT NEVER RELAX
fasten a fastener in place

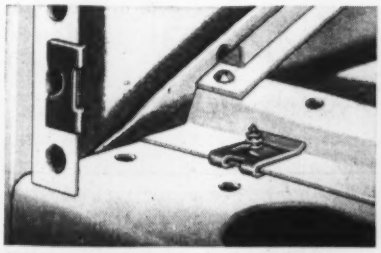
Alligator jaws have nothing on Tinnerman "U" and "J" type fasteners in gripping power. These fasteners press easily into locked-on position over panel edge or center panel locations. Yet they provide positive self-retention, ending the need for welding, staking or other secondary fastening devices. They are ideally suited for blind assembly or hard-to-reach locations.

When combined with the familiar Tinnerman SPEED NUT, this unique fastening principle provides a one-piece, self-locking, self-retaining fastener that is fast and easy to apply. The "U" or "J" feature can be combined with wire and tube retainers, latches, catches and a host of other fastening requirements to save time, material and production costs.

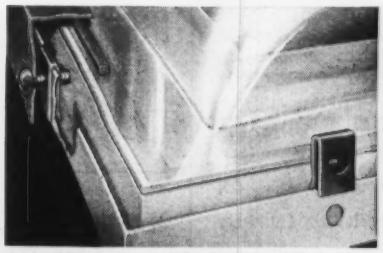
Find out about these and more than 8,000 other types of SPEED NUT brand fasteners now serving industry all around the world. They can make important savings for you, can also simplify your assemblies. See your Tinnerman representative soon or write to us. **Tinnerman Products, Inc., Box 6688, Dept. 12, Cleveland 1, Ohio.**

TINNERMAN
Speed Nuts®
FASTEST THING IN FASTENINGS®

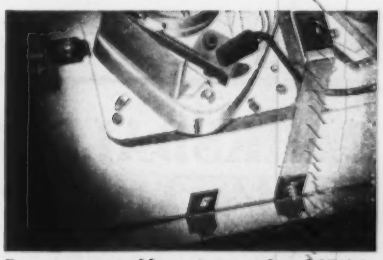




Greater flexibility for control equipment enclosures is provided by self-retaining "J" type SPEED NUTS at 30% less production cost.



Assembly costs on this sheet-metal skylight frame are reduced 66% by Tinnerman "U" type SPEED NUTS.



Gas range assembly costs are reduced 25% to 50% by using Tinnerman "U" and "J" type SPEED NUTS.

—ITEM 687—

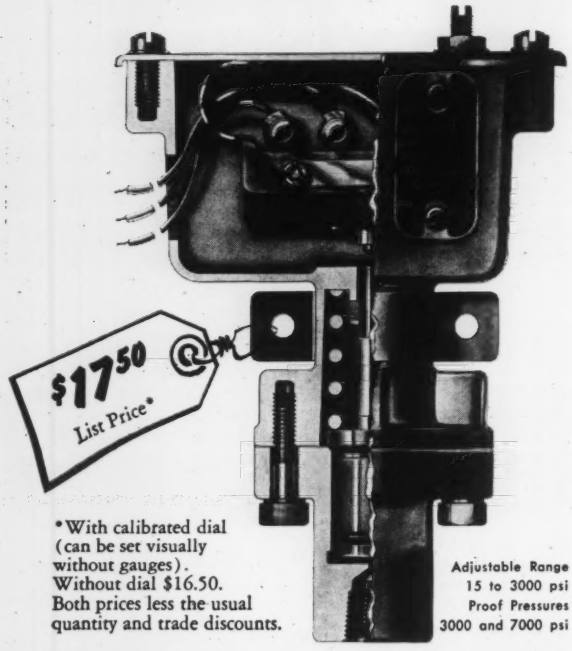
If you build

PRODUCTION EQUIPMENT

compare this pressure switch

for RUGGEDNESS,

DEPENDABILITY and COST



*With calibrated dial (can be set visually without gauges). Without dial $16.50. Both prices less the usual quantity and trade discounts.

Adjustable Range
15 to 3000 psi
Proof Pressures
3000 and 7000 psi

WE BUILD IN	WE DON'T USE
RUGGEDNESS Can take surges— (High proof pressures) Continuous operation— (Millions of cycles) No sticking— (in dirty fluid)	 **LINKAGES & BEARINGS** Which wear quickly—(cause settings to drift and switch to fail).
LABOR & MATERIAL SAVINGS No return drain piping— (Sealed piston) Mounts where convenient (Operates in any position, Not sensitive to vibration)	 **UNSEALED PISTONS** Which add to your installation cost (return piping). Are critical to dirt— (pistons get stuck).

BARKSDALE VALVES

PRESSURE SWITCH DIVISION
5125 Alcoa Avenue, Los Angeles 58, California

Ask for bulletins 9612 and C9612.

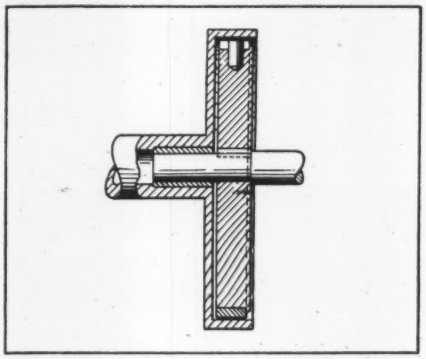
—ITEM 688—

Noteworthy Patents

tion of rotation, the pawl retracts, permitting the gears to turn freely. Rotation in the opposite direction, however, revolves the pawl to engage a finger projection with the teeth of the train gear, blocking any further motion in that direction. *Patent 2,722,297 assigned to the R. W. Cramer Co. Inc. by Eugene H. Gates Jr.*

Centrifugal Clutch

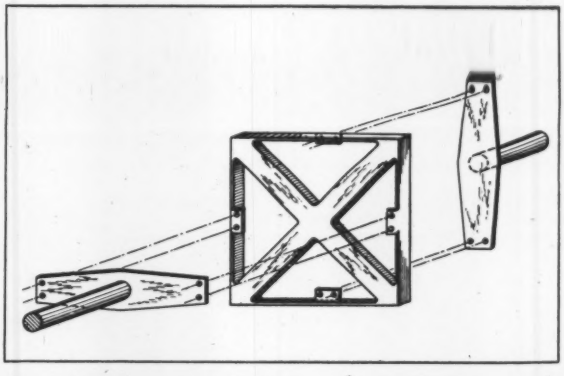
Floating bands of metallic friction material are utilized for torque transmission in a centrifugal clutch design. Mounted loosely around the periphery of a disk keyed to the drive shaft, the bands take the form of a split ring and are held in position by flanges and radial lugs on the disk. As the disk rotates, the bands move outward under centrifugal force to



engage the surface of a driven drum. Torque is transmitted to the drum through the radial lugs which engage the ends of the friction bands to prevent sideways motion. In operation, the forces produced on the bands by the lugs assist the centrifugal action. *Patent 2,720,301 assigned to the Continental Supply Co. by John C. Slonneger.*

All-Metal Flexible Coupling

Elastic deformation of flat metallic members is utilized in a flexible coupling construction to accommodate relative movements of connected shafts. Design of the members maintains torsional rigidity

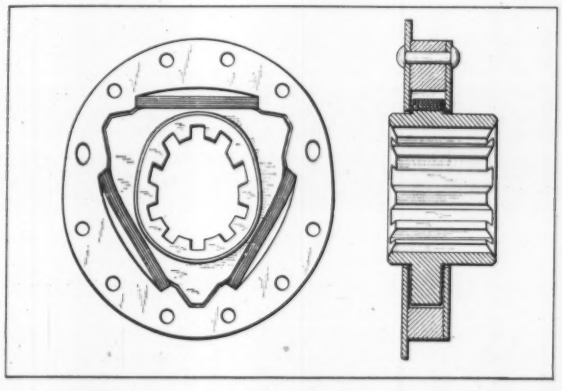


but permits lateral, angular and axial shaft displacements. The assembly consists of two flat metal strips, mounted to each shaft, which are connected

at their ends by a square metal frame structure with X-shaped braces. The strips are displaced 90 degrees on the frame. Transverse shaft movements are accommodated by deflection of the frame members; axial and angular movements by deflection of the strip members. Degree of flexibility in each direction can be readily varied by modifying the size, shape and other design characteristics of the different members. *Patent* 2,721,457 *assigned to Curtiss-Wright Corp. by Vincent Moore.*

Clutch Vibration Damper

Built-up layers of leaf springs absorb vibration and shock loads in a damper assembly for rotating drive units. Mounted to the drive shaft, a splined hub of triangular shape fits loosely into a mating opening in a disk attached to the driven member. The flat faces of the hub bear against the inner surfaces of sets of end-supported leaf springs which are free to flex in curved recesses in the disk. In

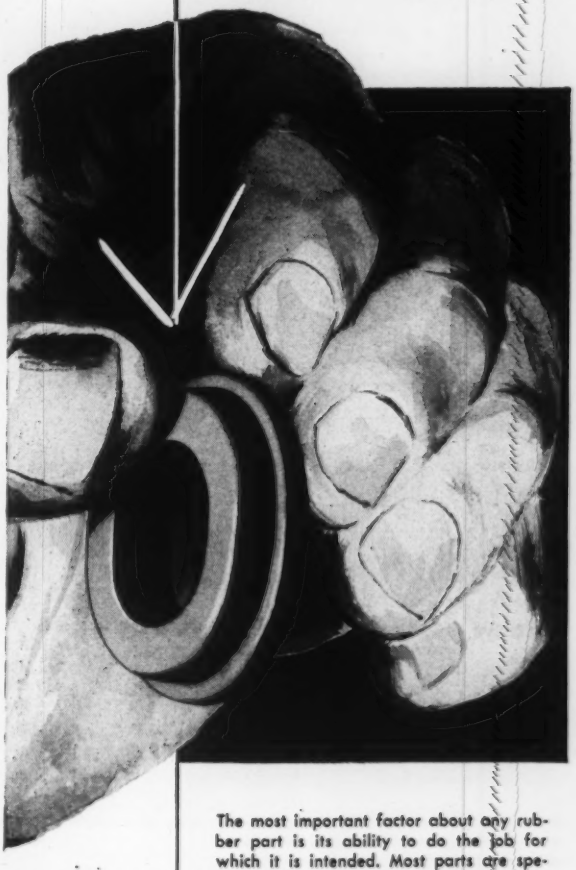


normal operation, driving forces are carried by the corners of the hub which engage the inner surfaces of the disk opening. However, relative motion of the disk and hub due to shock and vibration is cushioned by spring action. The construction assures a positive drive connection in the event of spring failure. *Patent* 2,724,252 *assigned to Mack Mfg. Corp. by Alois H. Schmal.*

Magnetic-particle clutch utilizes a fluid mixture of clear water and iron powder as the power transmitting medium. The water, which is continuously fed to the fluid mixture at a slow rate, serves as a coolant to dissipate heat generated by clutch slip. A rust inhibitor prevents deterioration of the iron powder. *Patent* 2,718,946 *assigned to Eaton Mfg. Co. by Martin P. Winther.*

Sprag clutch permits selective control of engagement and disengagement. Position of the gripper elements is controlled through a sliding cage construction. As the cage moves axially, it is rotated through a small angle by a cam arrangement to drive the grippers into, or out of, engagement. *Patent* 2,721,638 *assigned to Borg-Warner Corp. by James W. Palm.*

DOES THIS RUBBER PART BELONG IN YOUR PRODUCT?



8906-SR

The most important factor about any rubber part is its ability to do the job for which it is intended. Most parts are specifically engineered for the application . . . and consideration is given to elasticity, temperatures to be encountered as well as resistance to petroleum derivatives, chemicals and abrasion.

STALWART ENGINEERS have the experience and facilities to compound special rubber stocks to meet even the most unusual requirements . . . and from more than 500 different compounds already at their disposal, they can mold, extrude, die-cut, lathe-cut or mandrel-build shapes to meet any specifications.

SPECIFY STALWART RUBBER PARTS FOR THAT ONE ESSENTIAL QUALITY . . . THE ABILITY TO DO A JOB . . . BEST!

Write today for catalog 56-SR-3

STALWART RUBBER COMPANY
180 Northfield Road • Bedford, Ohio

—ITEM 689—

"MONOBALL" Self-Aligning Bearings

PATENTED U. S. A.
All World Rights Reserved

CHARACTERISTICS

ANALYSIS		RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications.

As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Address Dept. MD-56.

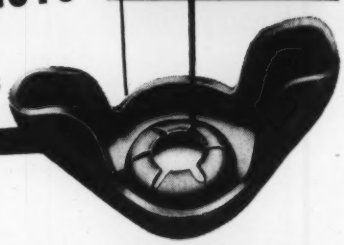
SOUTHWEST PRODUCTS CO.
DUARTE, CALIFORNIA

—ITEM 690—

PALNUT Vibration-proof WING NUTS

cost less than ordinary types

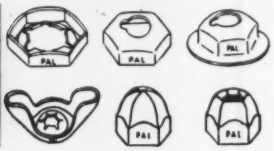
Built-in spring locking action holds tight until finger-released



An extra value for your customers—a real saving for you. Precision, spring steel PALNUT Wing Nuts spin on freely—lock securely when finger-tightened—stay tight in service—unlock with finger removal. Sizes: #6-32, #8-32, #10-32, #10-24, ¼-20 and 5/16-18. Finishes: cadmium, nickel, chrome or others to order. Send for free samples, stating sizes required.

THE PALNUT COMPANY 75 Glen Road, Mountainside, N. J.
Subsidiary of United-Carr Fastener Corporation
In Canada: P. L. Robertson Co., Ltd., Milton, Ont.

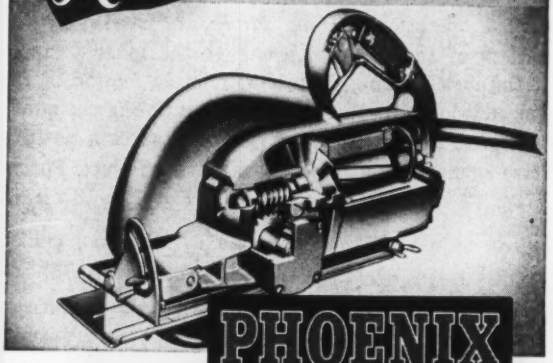
PALNUT TRADEMARK **LOCK NUTS**



—ITEM 691—

ANOTHER FAMOUS NAME

Mall TOOL COMPANY



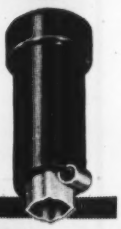
PHOENIX *Brush Holders*

Buys

Because

Mall makes tools for lasting service. And that means top quality in *every* product detail.

Send for Catalog 56L—shows how to order molded or assembled types.

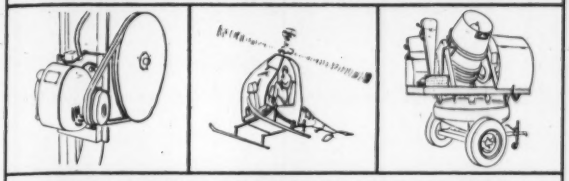


PHOENIX ELECTRIC MANUFACTURING CO.
4211 West Lake Street Chicago 24, Illinois

—ITEM 692—

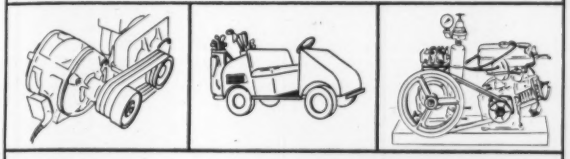
For More Information Circle Item Number on Yellow Card—page 19

SALSBURY CLUTCHES AND TRANSMISSIONS HAVE



SOLVED POWER TRANSMISSION PROBLEMS

FOR THESE AND MANY OTHER APPLICATIONS



Send us your power transmission problem. Let our experts supply the precise design to solve it. Write for special engineering assistance on unusual applications.

SALSBURY CORPORATION

1161 E. Florence Ave. • Los Angeles 1, Calif.

—ITEM 693—

SAVE 1/3 with the New UNIMAX WL SWITCH

UNIMAX Type WL

UNIMAX Type WLL

You get

3 BIG ADVANTAGES

with this UL-listed snap-acting switch!

1. Costs ⅓ less than other snap-switches.
2. Handles 15 amp. at 125/250 volts a-c.
3. Quick-connect terminals for snap-on wiring give *fast* installation.

Let us show you how the Unimax WL can cut your switch and assembly costs.

UNIMAX SWITCH

Division The W. L. Maxson Corporation

IVES ROAD, WALLINGFORD, CONNECTICUT

—ITEM 694—

cut tubing costs up to 40% over copper with ALCOA UTILITUBE

Whatever your tube needs may be, consider ALCOA Utilitube which offers substantial savings. Made of a special ALCOA Alloy, this coiled aluminum tube can save up to 40% over copper tube for lubricating lines, fuel lines, air lines or hydraulic fluid lines.

Compare these advantages:

LOW COST—actually costs up to 40% less per foot than copper tube.

LONG LENGTHS—available in economical long lengths up to 1,000 feet.

EASY WORKABILITY—bends easily, work-hardens less.

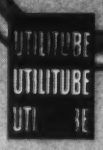
CORROSION-RESISTANT—resists most industrial atmospheres, many gases and liquids.

LIGHT WEIGHT—only ⅓ the weight of copper; long lengths easier to handle.

NO SLUDGE OR GUM—will not contribute to the formation of sludge or gum in lubricating oils, gasoline.

AVAILABILITY—your ALCOA distributor carries ample ALCOA Utilitube in stock.

FITTINGS—readily available in aluminum from several manufacturers.



Complete details in the FREE booklet, *Alcoa Utilitube*. Send for it.

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

ALCOA

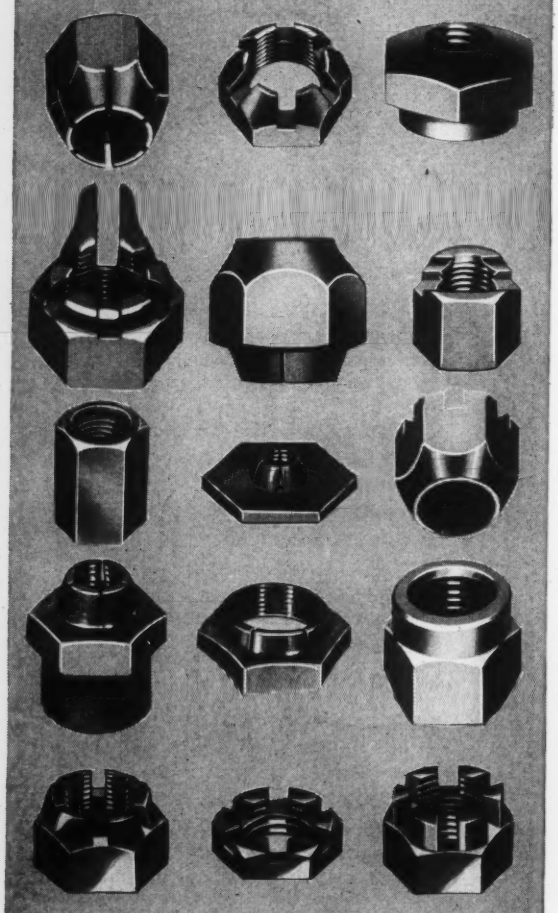
ALUMINUM COMPANY OF AMERICA
909-F Alcoa Building, Pittsburgh 19, Pa.

—ITEM 695—

SPECIAL NUTS

to specs. 7/16" - 4-1/4" cross flats

special machines + large stock of material × years of experience = speedy deliveries high quality low prices



Here are a few samples made to customers specifications . . Our batteries of special high-speed multi-spindle, automatic machines make possible fast and accurate production of hexagon nuts of non-standard height and special shape from carbon or alloy steel, Naval bronze or other non-ferrous metals; also AN 310 through AN 335 as per latest Airforce specifications. Very often the special nut you require may be similar to one we are already making and a simple modification would result in a price advantage and quicker deliveries to you . . Send us your blueprint and particulars —let us quote on your requirements . . We also have a catalog that contains complete specifications, engineering data and prices regarding our standard nuts.

NATIONAL MACHINE PRODUCTS COMPANY

Manufacturer of Standard and Special "12 Pointer and Hexagon Nuts . . . "Huglock" and "Marsden" locknuts.

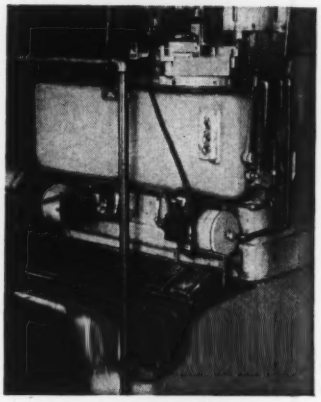
44255 Utica Rd., UTICA, Michigan

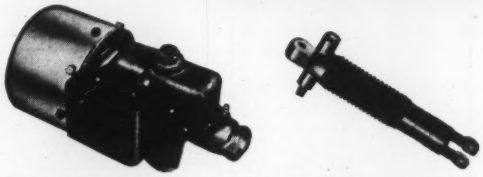
—ITEM 696—

Let Wagner solve YOUR ACTUATION PROBLEM

Wagner Electric Corporation offers a wide variety of air and hydraulic actuators and controls.

For specific applications, Wagner can furnish engineered kits with actuators, controls, tubing, fittings —everything required for complete installation. Your nearby Wagner field engineer will get you detailed specifications on a system for your particular application. Call him today.





Shown above is a broaching machine with swivel type clamping fixtures, utilizing the Wagner power cluster which converts air pressure to hydraulic pressure that is delivered to actuating cylinders on each of the clamping fixtures.

Wagner Electric Corporation
6404 PLYMOUTH AVE., ST. LOUIS 14, MO. 156-2

—ITEM 697—

VULCAN
ELECTRIC HEATING UNITS

Strip Heaters

For Heating

Flat Surfaces • Shallow Pans
Hot Plates • Ovens • Platens
Dies • Plastic Extruders • Melting
Pots • Tanks • Package Sealers etc.

RUGGED CONSTRUCTION

Rust-resisting sheath is of one-piece rectangular tubing, specially drawn to our specifications.

Heater coil, of nickel chromium wire, is insulated from the inner sheath wall with a refractory selected for best Terminal conduction and stability at elevated temperatures. Terminal screws are stainless steel, to ensure strength and avoid oxidation.

115 and 230 volts. Five terminal arrangements

Steel sheath (150 to 1250 watts) for temperatures up to 750° F max. High temperature sheath (250 to 1500 watts) for temperatures up to 1200° F max.

VULCAN ELECTRIC COMPANY
DANVERS 6, MASS.

By the makers of Vulcan Electric Heating Units, Soldering Tools, Solder Pots, Glue Pots, Branding Irons and Electric Heating Devices. See 8-page Vulcan catalog in Sweet's Product Design File for 1955

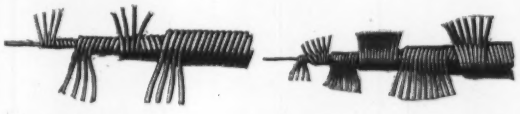
—ITEM 698—

For More Information Circle Item Number on Yellow Card—page 19

STRENGTH WOUND INTO IT

Research has proved that a light flexible wire with several alternate layers of wire wound around it produces a cable more flexible than a single wire of the same diameter and is capable of carrying a much higher torque. Flexible shafts are composed of this type cable plus a flexible casing which provides protection from dirt, grime, or grease.

There are two types of flexible cables used in flexible shaft assemblies. One is the power drive flexible cable in which the wires are wound in alternate direction. The outer layer of wire determines the direction rotation and is made to tighten when in use to add strength and form a practically unbreakable unit. The main advantage of the power drive flexible cable is its simplicity of alignment, as it is capable of transmitting power over, under, and around any obstacle between the drive and the driven elements.



Power drive cable with wires partly unwound to show construction of the cable.

Section of remote control cable showing superimposed layers of wire wound in opposite direction.

The other type of flexible cable is the remote control flexible cable which due to being constructed of smaller gauged wires than the power drive cable, and wound by a special process, provides for both rotation and reciprocation such as the opening and closing of a valve.

Both of these flexible shafts may function in a continuous or intermittent operation with a minimum amount of vibration. They not only offer long lasting strength but also economies in cost, time and space.

Send for further details on how flexible shafting may be easily and economically incorporated into your design.

Write F. W. Stewart Corporation, 4311-13 Ravenswood Avenue, Chicago 13, Illinois.

—ITEM 699—

Here's the Answer to Accurate Timing of Electrically Operated Equipment

ZENITH INTERVAL TIMER

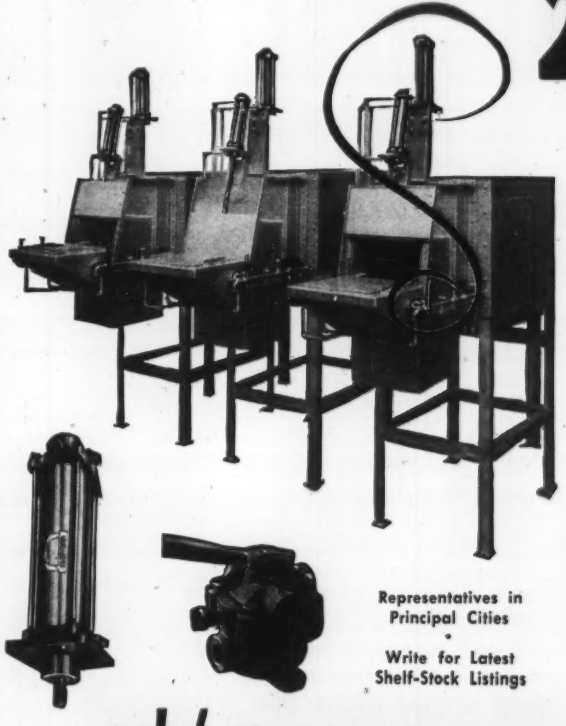
Especially recommended for operation of blowers, pumps, agitators, mixers, conveyors and other machinery . . . widely used for plastic moulding, rubber curing, heat treating, enamel baking, light exposure and similar operations.

Fully enclosed. Double-throw, single-pole switch. Self-starting slow speed industrial type synchronous motor. Time range: 60 seconds to 72 hours.

Send for full information, including bulletin on Zenith's complete line of automatic control equipment.

ZENITH ELECTRIC CO.
149 WEST WALTON STREET • CHICAGO 10, ILLINOIS

—ITEM 700—



20 YEARS Trouble-Free Service on Hevi Duty Electric Furnaces

Hevi Duty Electric Co., Milwaukee, builder of Electric Heat Treating Furnaces, has found that NOPAK Cylinders and Valves can be depended upon for the many years of trouble-free service which users expect of Hevi Duty Furnaces. Not once in 20 years has a Hevi Duty customer returned a NOPAK Component for replacement.

The furnaces pictured are used to harden steel dies employed in the manufacture of jewelry. Outer doors, inner partitions and conveyor trays . . . all are actuated by NOPAK Cylinders controlled by externally mounted NOPAK Valves.

Another reason why Hevi Duty specifies NOPAK Products is the simplicity and ease of their installation . . . an important factor in cutting assembly costs.

Examples showing how NOPAK Products are used in other types of machinery and equipment are described in the NOPAK Application Manual. Ask your NOPAK representative, or write for your copy.

GALLAND-HENNING NOPAK DIVISION
2752 SOUTH 31ST STREET • MILWAUKEE 46, WISCONSIN

Representatives in Principal Cities
•
Write for Latest Shelf-Stock Listings

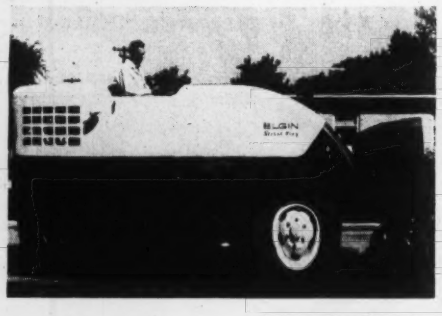
NOPAK
® VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE

A 8633-½-H

—ITEM 701—

ROCKFORD

MEMO— Clutch must have accurate balance



Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

SPRING

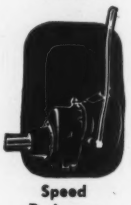
LOADED

Oil or Dry Multiple Disc

Heavy Duty Over Center

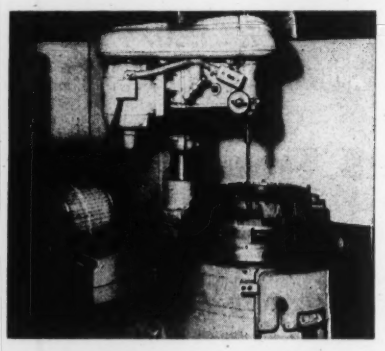
Light Over Center

Power Take-Offs



Speed Reducers

All ROCKFORD clutch plates not only are carefully checked for accuracy of dimensions, but are inspected on an electronic balancing machine.



Uniform operation, minimum wear, less frequent adjustment and long life qualities of ROCKFORD CLUTCHES thus are protected during production.

Let our engineers show you how ROCKFORD quality safeguards insure low maintenance for ROCKFORD clutch equipped machines.

B. W. ENGINEERING MAKES IT WORK

ENGINEERING

B-W

PRODUCTION

B. W. PRODUCTION MAKES IT AVAILABLE

ROCKFORD
Clutch Division
BORG-WARNER
311 Catherine St., Rockford, Ill.

CLUTCHES

—ITEM 702—

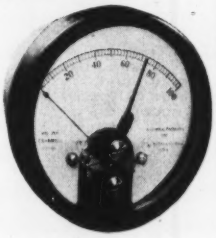
NEW METER-RELAYS

FROM 0-5 MICROAMPERES - UP

Ruggedized-Sealed, Black Bakelite, or Clear Plastic Cases

D'Arsonval indicating meters with built-in locking contacts for sensitive and accurate control or alarm

TRIP POINT ADJUSTABLE to any point of scale arc. Sensitive to changes as little as 1%. One contact carried on moving pointer. The other on an adjustable pointer. When two pointers meet, contacts close and lock. Holding coil is wound directly over moving coil, locking action is electro-magnetic. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully.



Model 255-C, Single Contact, High Limit, 0-10 Volts DC $42.50

Model 461-C, Double Contact 10-0-10 Microamps DC $83.25

Ranges from 0-5 microamperes or 0-5 millivolts up, full scale. Temperature ranges from 0-300°F. (10 ohms external) have bimetal cold junction compensation.

Standard Contact Rating 5 to 25 milliamperes DC. Can be built up to 100 milliamperes DC.

Ruggedized-Sealed metal cases are 2½", 3½" and 4½" round, shock-mounted, gasket-sealed.

Black Bakelite case, 4½" rectangular.

Clear Plastic cases are 2½", 3¾", and 4½" rectangular. Maximum visibility and lower cost.

Panel meters and indicating pyrometers are also available in ruggedized-sealed, black bakelite or clear plastic cases. New 40-page catalog lists prices and specifications for meter-relays, meters, pyrometers and automatic controls using meter-relays. Write for Catalog 4-A, **Assembly Products Inc.**, Chesterland 51, Ohio. HAmilton 3-4436 (West Coas': Desert Hot Springs 51, Calif. Phone: 4-3133).

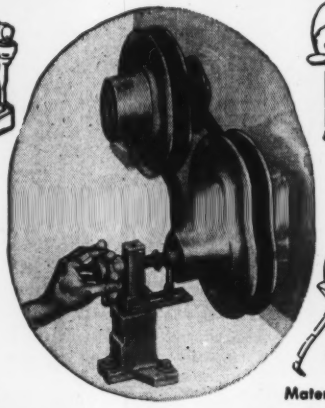
—ITEM 703—

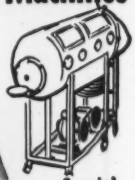
SPEED SELECTOR

VARIABLE PITCH SHEAVES

Control Speeds on Variety of Machines

Mowers and Tractors





Special Equipment

Machine Tools

Materials Handling

New! Wide Speed Range! Low Cost Sheaves

Speed Selector Sheaves can give your machines or equipment extra wide-range speed control on fixed centers. Efficient, rugged, simple to use — low in cost! Write for Illustrated Bulletin.

CATALOG FREE! WRITE TODAY

SPEED SELECTOR INC.

120-B NOBLE COURT • CLEVELAND 13, OHIO

—ITEM 704—

New MARCO TYPE Y5 SHADED POLE MOTOR

1/25 to 1/4 h.p.

- Higher Efficiency
- Better Stability
- Cooler Operation

LOW in COST

• This new, large diameter (5-1/2"), more powerful motor has all the features of the famous Marco Motors used in hundreds of thousands of air conditioning units — in fans, blowers and furnaces.

Power up to 1/4 h.p. can be supplied — or — in the new "wafer thin" design (as short as 2-1/2 inches) 1/15th horsepower.

Get the facts on this motor today!

MARCO INDUSTRIES, INC.

8th & Franklin Sts., Womelsdorf, Pa.

—ITEM 705—

Modernair

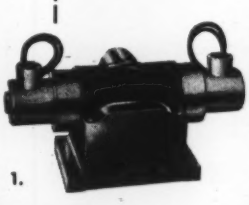
MV CONTROL VALVES

Easier to apply... Compact, versatile; choice of 3 mountings and 7 manual, solenoid, cam or pilot operating means for pneumatic, hydraulic systems to 200 p.s.i.

Easier to install... Sub-base, console and panel, or conventional piped mountings available.

Made in ⅜", ½", ¾" and 1" NPT port sizes.

Easier to service... Only moving part is one-piece spool carrying all moving seals which are standard "O" rings stocked by industrial supply houses; replaceable in minutes—no springs or retainers.



1.

4-way double solenoid MV is only 9¾" x 3½" x 2⅝" overall (⅛" NPT ports); handles to 150 p.s.i.

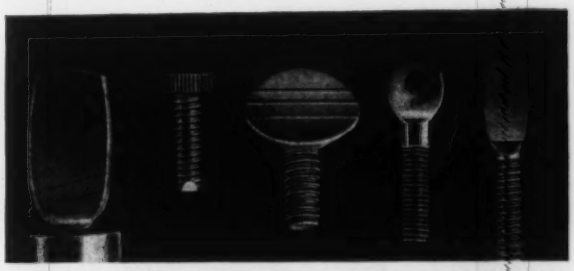
Don't lose time and money with misfits or specials when a stock MODERNAIR MV valve will do your job. Modernair valves, cylinders and parts are stocked in principal U.S. and Canadian cities, and at factory. For prompt delivery, call your authorized dealer or write us now for specifications and prices.

Modernair CORPORATION

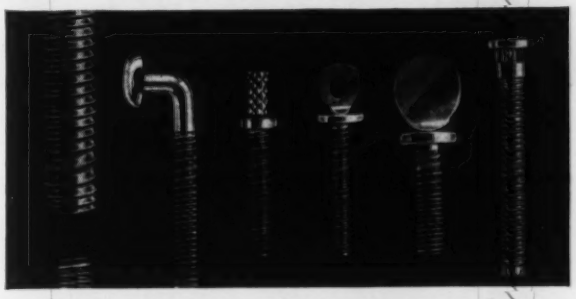
*Trademark

Dept. E-6 400 PREDA ST. • SAN LEANDRO, CALIF.

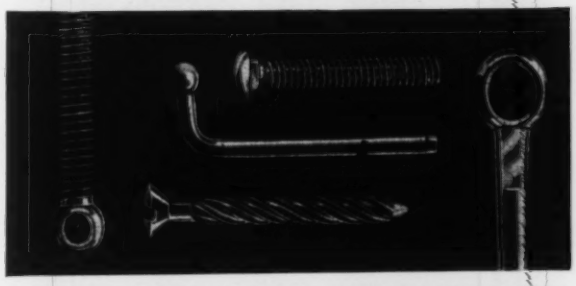
—ITEM 706—



YOU CAN'T BEAT COLD FORMING

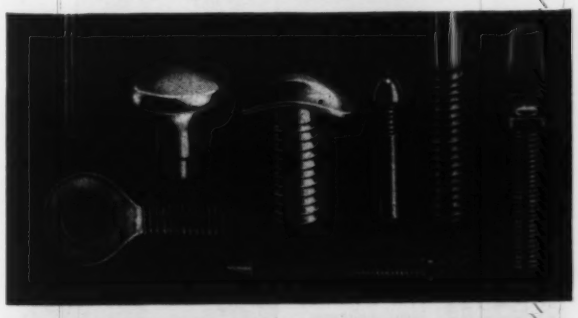


FOR PARTS LIKE THESE—AND

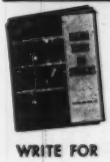


YOU CAN'T BEAT PROGRESSIVE

FOR COLD FORMING . . .



MACHINE SCREWS AND SPECIAL FASTENERS ARE OUR BUSINESS
INCLUDING SQUARE AND HEXAGON MACHINE SCREW NUTS



WRITE FOR OUR CATALOG

THE PROGRESSIVE MANUFACTURING COMPANY

DIVISION OF THE TORRINGTON COMPANY

52 Norwood St., Torrington, Conn.

—ITEM 707—

MARSH *Mastergauge*

Always the best of the better gauges, Mastergauge has been given *plus* features that further lengthen its lead.

A still better tube construction: Socket, tube and end piece are now all fused into *one* leak-tight unit by the new Marsh "Conoweld" process.

A still better case: New copper clad wrought steel "Marshalloy" case has the corrosion resistance of pure copper; weighs one third as much as cast iron, and is *four times* as strong.

An even finer movement: Further refinements are added to the rugged, corrosion resistant, virtually frictionless stainless steel and monel Mastergauge movement. A typical refinement is the "coined" (extruded) sector gear which contributes extra strength and precision.

Where only the best is good enough—in the most critical industrial refinery and oil country services —"Mastergauge" is your instrument.

The JAS. P. MARSH Corporation SKOKIE ILLINOIS 90th 1865 1955

WRITE FOR NEW CATALOG

MARSH INSTRUMENT CO. Sales affiliate of Jas. P. Marsh Corporation
Dept. B, Skokie, Ill.
Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alta.

—ITEM 708—

Belleville Springs by Solon Mfg. Outstanding for Many Applications

Ever consider using Belleville Springs for brakes and clutches? They're especially effective on the flat part of the load-deflection curve—where load remains constant over an appreciable deflection. With proper design, you can get all the load and deflection normally required yet allow for considerable tolerances as well.

Solon Mfg. specializes in manufacture of PRECISION Belleville Springs. We would be glad to work with you on your requirements. Write today for your free copy of our design manual, "Belleville Springs," which lists our standard manufacturing tolerances on different grades—as well as necessary curves for their design.

Solon Manufacturing Company

South Miles Road • Solon, Ohio

—ITEM 709—

WHEN YOU NEED *Quicker Fastening* FOR

- **Blind Assemblies or**
- **Extra Threaded Depth at less cost...**

use one of these 2 WELD NUTS

Gripco Pilot-Projection Weld Nut. Circular pilot designed for quick, easy positioning of nut over bolt hole for instant resistant welding. No jigs, no fumbling, no waste of time. Furnished with or without famous Gripco locking feature.

Gripco Countersunk Weld Nut. Eliminate time-wasting retapping of nuts after welding. Exclusive countersunk nut bottom does away with fouling of nut threads by weld spatter. Available with or without Gripco locking feature.

Write for sample and full details. NO. 114

GRIP NUT COMPANY

103 Maple Ave., South Whitley, Ind.

—ITEM 710—

MAYLINE

MAYLINE
Metal Plan Files are Outstanding

For their construction, usefulness, and appearance. Heavy gauge steel used throughout. Extra reinforcing on corners and bases. Drawers have finger-tip control. Hinged dust cover keeps drawings flat and dust free. Cabinets attractively finished in modern office gray.

See your local dealer today for prices and delivery.

Symbol of Superiority

MAYLINE CO. INC.

601 NO. COMMERCE ST.
SHEBOYGAN, WISCONSIN

MAYLINE

MAYLINE

MAYLINE

—ITEM 711—

Parts made of

Dixon RULON

never need lubrication

Specify RULON for –

- VERY LOW FRICTION
- HIGH WEAR RESISTANCE
- GREAT CHEMICAL INERTNESS
- EXCELLENT DIELECTRIC PROPERTIES
- GOOD HEAT PROPERTIES UP TO 350°–500°F

Rulon is inherently slippery, requires no lubrication. This remarkable plastic offers most of the advantages of Teflon but has far greater wear resistance and better resistance to cold flow.

If you need one or all of Rulon's special properties for bearings, bushings, slides, guides, cam followers, washers, spacers, or other parts — consult us without obligation.

We supply both Rulon and Teflon in rods, tubes, sleeving, tape, extruded and molded shapes. Write for detailed information.

DIXON CORPORATION
BRISTOL 3, RHODE ISLAND

—ITEM 712—

Increased Insulation

BETTER CONNECTIONS

JONES BARRIER TERMINAL STRIPS

Leakage path is increased — direct shorts from frayed terminal wires prevented by bakelite barriers placed between terminals. Binder screws and terminals brass, nickel-plated. Insulation, BM 120 molded bakelite. Finest construction. Add much to equipment's effect.

Jones Means Proven Quality

No. 2-142 No. 2-142-¼ W No. 2-142-Y

Illustrated: Screw Terminals—Screw and Solder Terminals—Screw Terminal above Panel with Solder Terminal below. Every type of connection.

Six series meet every requirement: No. 140, 5-40 screws; No. 141, 6-32 screws; No. 142, 8-32 screws; No. 150, 10-32 screws; No. 151, 12-32 screws; No. 152, ¼-28 screws.

Catalog No. 21 lists complete line of Barrier Strips, and other Jones Electrical Connecting Devices. Send for your copy.

Jones — HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
CHICAGO 44, ILLINOIS
SUBSIDIARY OF UNITED-CARR FASTENER CORP.

—ITEM 713—

THIS SIMPLE REQUEST...

Please quote on the attached gear drawings in quantities of ....

— — can bring you

- **BETTER GEARS** that cost you less
- **BETTER MACHINES** that produce more — — and sell more

Get the habit—always include Sier-Bath when a gear print, problem or price is under consideration, in all quantities starting with 12 to 25 of a kind (depending on size).

Sier-Bath engineers will study your application—engineer your drawings and gears free, to determine the most economical gears to operate safely, efficiently and advantageously.

Your gears will be produced and inspected on the most advanced equipment available anywhere—delivered with dependable uniformity to measured requirements, at prices that make it uneconomical to use less efficient gears.

GEAR RANGE

Straight and Coniflex Tooth Bevel Gears, 2" to 23", depending on ratio
Spur Gears, to 54" diameter
Helical Gears, to 54" diameter
Worm Gears, to 54" diameter
Worms to 12" diameter
Ground Thread Worms to 6" dia.
Herringbone Gears, to 36" dia.
Instrument Gears—1" dia. and up
Internal Gears—to 36" O.D.
Gear Grinding. Involute and square splines, ground and unground

Sier-Bath PRECISION GEARS

Sier-Bath GEAR and PUMP CO., Inc.
Founded 1905 9237 Hudson Blvd., North Bergen, N. J. Member A.G.M.A.
Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings

—ITEM 714—

10,000 lbs. pressure with CADDY® MODEL P-5

SPECIFY CADDY® TOGGLE CLAMPS FOR

LONGER LIFE
MORE PRESSURE
FASTER ACTION

Send for your FREE 1956 Template catalog today

CADDY®

Erico Products, Inc.
2070 E. 61st Place • Cleveland 3, Ohio
IN CANADA: ERICO INCORPORATED, 3571 Dundas St., West, Toronto 9, Ontario

—ITEM 715—

With ARENS ..Remote Controls you can...

PUSH • • • • • • PULL

LOCK • • • • ADJUST

at lower cost

Arens low cost standard controls give you the benefit of quantity production. We also engineer "specials."

Write for Catalog
40 page illustrated Arens Push-Pull Remote Controls Catalog. Write for it.

ARENS CONTROLS, INC.
2009 Greenleaf Street • Evanston, Illinois

—ITEM 716—

ENGINEERS
AVAILABLE OR WANTED

WANTED: Mechanical Engineer. Position open for an engineer in the Reactor Development program of a large midwest research and development Laboratory. This position is with a small group of engineers and physicists who to date have been responsible for some of the most outstanding and significant experiments in the field of nuclear power reactors. The opportunity to become a member of this team presents a real challenge to the young engineer with a strong academic background and preferably some general engineering experience. Salary is commensurate with training and experience. Address Box 900, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Design Engineer, preferably graduate M. E. with experience on medium size and special machinery. Location upstate New York. Excellent opportunity for rapid advancement. A. J. Wahl, Inc., 8 Central Avenue, Brocton, New York.

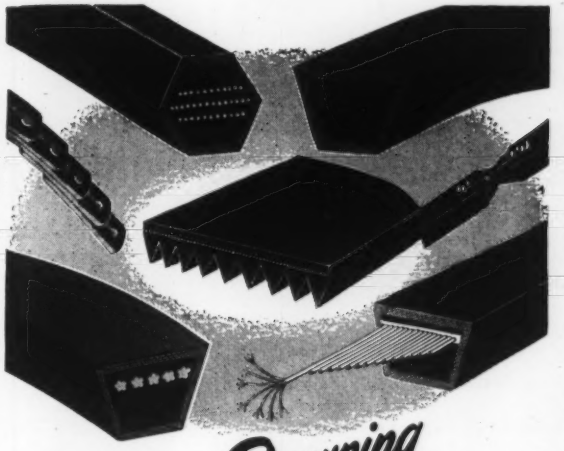
WANTED: Mechanical Engineer. Position open for a design engineer in the Central Shops facility of a midwest research and development laboratory. Ability to design and follow through fabrication on a wide range of scientific equipment for use in research in Physics, Chemistry, Biology, Chemical Engineering and Metallurgy. Salary commensurate with training and experience. Address Box 901, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Mechanical Engineers and Mechanical Draftsmen. Growing company expanding Engineering Division. Opportunity for rapid advancement into management and development work on mechanical parking garages, aircraft hangars, industrial buildings, TV broadcast antenna towers. Liberal benefits including retirement. Moving expenses paid. Write: E. L. Smith, Dresser-Ideco Company, One of the Dresser Industries, 875 Michigan Avenue, Columbus 8, Ohio.

WANTED: Mechanical Engineer. Position open for a design engineer in the Remote Control Engineering Division of a midwest research and development laboratory. Challenging opportunity requiring ingenuity and imagination in the design of intricate mechanisms for remote controlled metal cutting machines, test apparatus, shielded facilities and manipulators. Publications encouraged. Salary commensurate with training and experience. Address Box 902, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Mechanical Engineer. Position open in Operations Division of a midwest research and development laboratory for a graduate with a minimum of five years experience in the design and construction of mechanical facilities, including industrial type air conditioning, ventilating and heating systems; process piping, and pneumatic control systems for a wide variety of equipment installations; and water and steam distribution systems. Duties include the obtaining of operational and other design requirements for the construction of new facilities and the rearrangement of existing facilities; preparation of designs, specifications, and cost estimates; and performing field inspection of construction contracts. Salary commensurate with training and experience. Address Box 903, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Project Engineer (Machine Design) for project responsibilities in the machine design and development division of a well known rapidly expanding firm whose activities in the development of food production and packaging machines have helped make it one of the front runners in its field. Madison, Wisconsin location. Engineering degree required with specialization in equipment and machine design. Write Box 904, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.



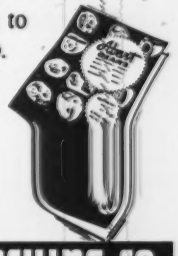
There's a *Browning* GRIPBELT for every purpose!

No other source offers such a wide selection of V-belts . . . from FHP to steel cable belts, including versatile Griplink and Griproll, and unique new Poly-V. These combine with Browning's variety of sheaves to form the most complete V-drive line. For every power transmission need, contact your Browning distributor. He will serve you promptly, efficiently. *Write for free catalog GC101, showing whole line.*

Browning MANUFACTURING COMPANY
MAYSVILLE, KENTUCKY

—ITEM 717—

No stocks! All Abart Gears—spur, spiral, bevel, helical, internal, worm, rack, sprocket—are specially and precisely cut to your specifications. Any material—any quantity—96 pitch to 5/7 D.P.—¼" P.D. to 18" P.D. Send B/P and specs or sample for estimate. Request data-packed handbook.

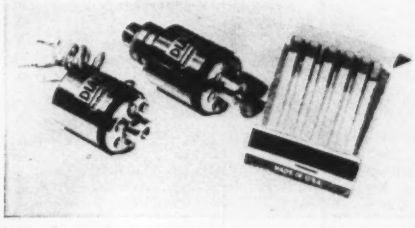


ABART GEAR and MACHINE CO.
4821 WEST 16th STREET CHICAGO 50, ILLINOIS

—ITEM 718—

MAGNETIC CLUTCHES & BRAKES

Miniature in size, they are giants in performance.



A line of seven standard types, each in two sizes, now gives the design engineer an opportunity to utilize a miniature clutch at the utmost economy in applications where a simple disconnect or non-chattering brake is required. Special models are also available for continuous slip or for accurate tension or torque control.

The units range upward from one weighing only 2½ ounces with less than 1" OD which delivers 30 inch-ounces of torque on about 2 watts of power.

FOR INFORMATION ON THE FULL LINE SEND FOR OUR NEW CATALOG NO. 955. It contains complete specifications and performance charts.

DIAL PRODUCTS COMPANY
9A Avenue E (HEmlock 7-0720) Bayonne, N. J.

—ITEM 719—

LESS torque-scatter WITH THE

M·F

(Production men, of course, know that a lock nut with a "scatter-pattern" interrupts production and increases rejects.)

. . . and constant-torque M-F costs NO MORE!

A complete line of lock nuts and semi-finished hexagon nuts. Write for catalog and samples.

Uni-Torque®
LOCK NUT

Why do *designers* want a lock nut that shows an *even* pattern of torque, nut after nut, keg after keg?

Because it means *uniform bolt tension*, which is important in keeping the finished product true to original design.

MAC LEAN-FOGG
Lock Nut Company
5535 N. Wolcott Street
Chicago 40, Illinois

—ITEM 720—

Remote or automatic switching

AT HALF THE COST

with Westinghouse motor-operated AB circuit breakers

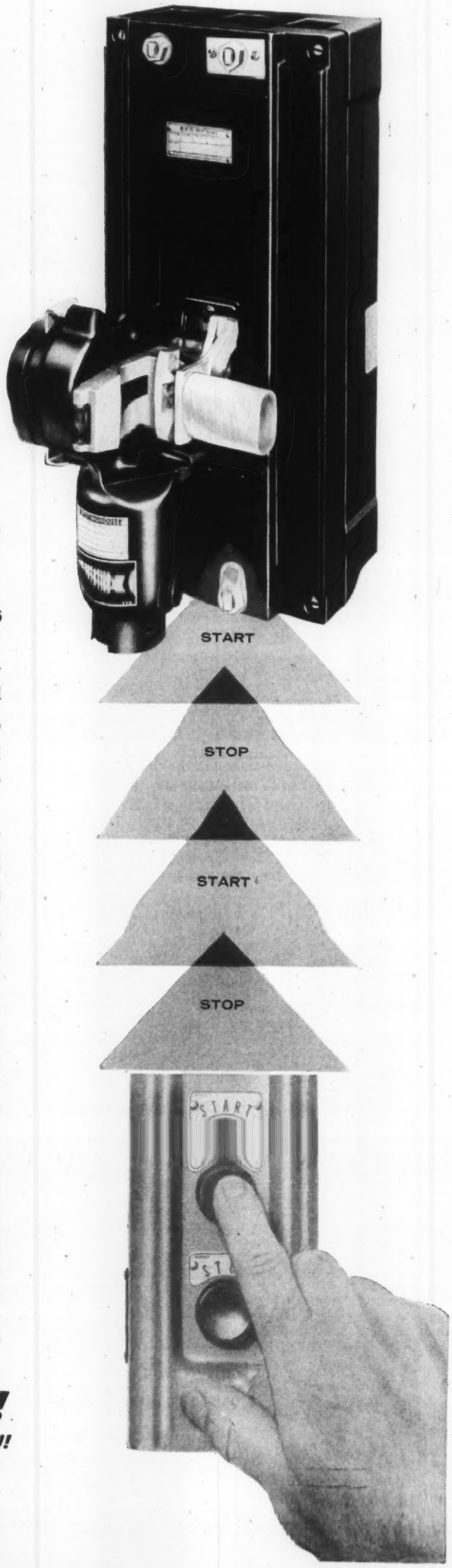
Now you can use a pushbutton or relay to electrically operate a Westinghouse AB circuit breaker. You can add load switching to your circuit protection — from a convenient point or under pre-determined conditions. And all without the need for a costly breaker-contactor combination or an expensive, large air circuit breaker.

Cost of the motor operator is but a small fraction of that for a large contactor. In fact, the complete dual-purpose breaker (breaker and motor operator) cost less than a contactor alone. Don't forget either the valuable space you save by eliminating contactors or by replacing larger breakers.

With the Westinghouse motor-operated circuit breaker you get all the proved AB De-ion® protection features. In addition you have your choice of such internal aids as reverse-current trips, undervoltage trips, and auxiliary or alarm switches. The motor operator can be applied to breaker Types J, K, KL, L and M in ratings of 70 through 800 amperes.

If it's remote or automatic breaker switching you need, consider the real savings possible with motor-operated AB circuit breakers. Your local Westinghouse sales office will be glad to help — or write direct to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

J-30213



WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING FOR **YOU!***

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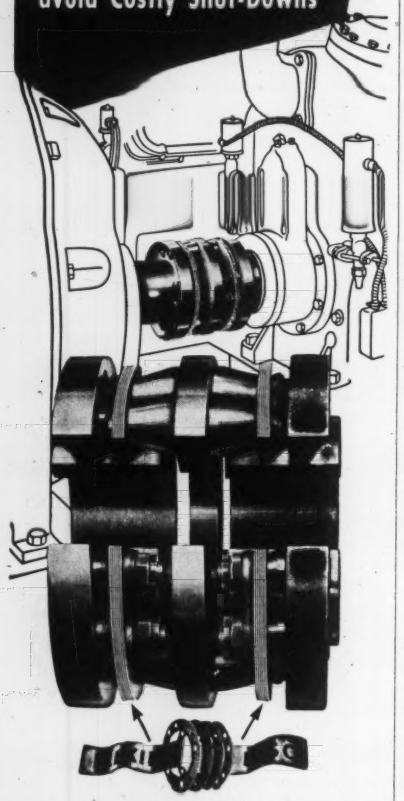
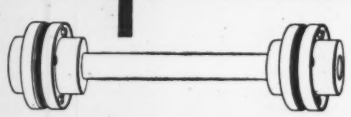
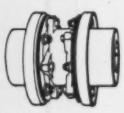


Patented Flexible Disc Rings of special steel transmit the power and provide for parallel and angular misalignment as well as free end float.

DISTINCTIVE ADVANTAGES

FACTS	EXPLANATION
NO MAINTENANCE	Requires No Attention. Visual Inspection While Operating.
NO LUBRICATION	No Wearing Parts. Freedom from Shut-downs.
NO BACKLASH	No Loose Parts. All Parts Solidly Bolted.
CAN NOT "CREATE" THRUST	Free End Float under Load and Misalignment. No Rubbing Action to cause Axial Movement.
PERMANENT TORSIONAL CHARACTERISTICS	Drives Like a Solid Coupling. Elastic Constant Does Not Change. Original Balance is Maintained.





Thomas Couplings are made for a wide range of speeds, horsepower, shaft sizes and can be assembled or disassembled without disturbing the connected machines, except in rare instances.

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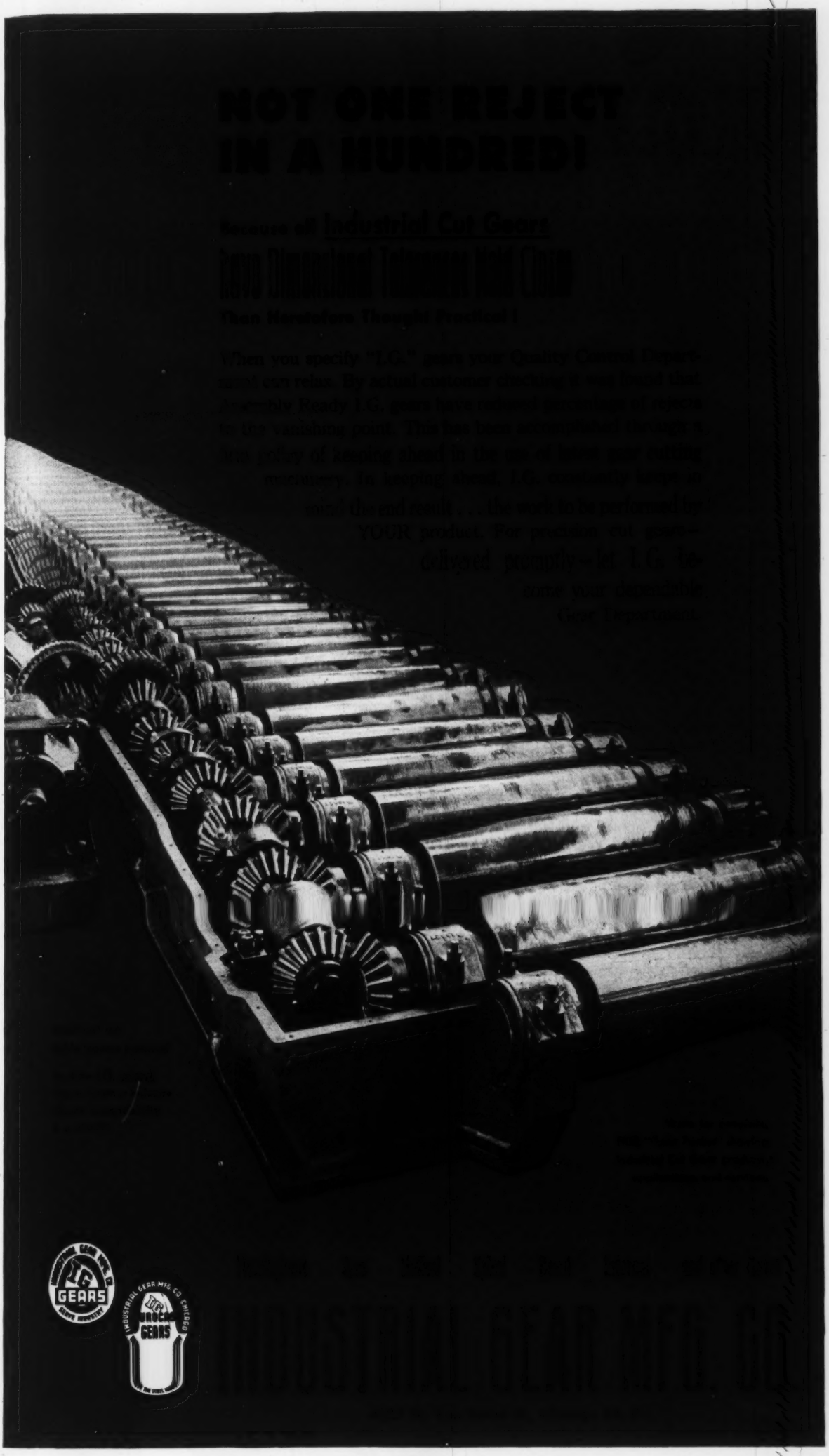

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65-year test

directs choice of valves for new Rochester home of

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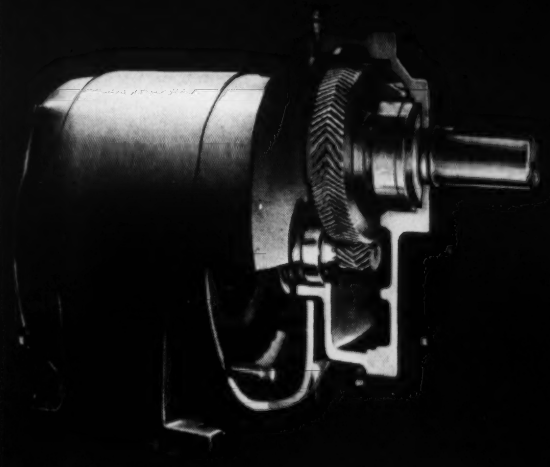

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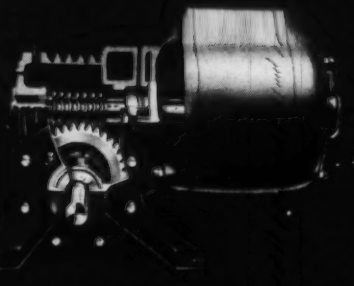

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